ALTERNATIVE GENERATION AND DIESEL HEAT RECOVERY IN REMOTE ONTARIO COMMUNITIES

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and

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CONTENTS

		Page
	LIST OF TABLES	v
	LIST OF FIGURES	vii
	LIST OF ABBREVIATIONS	x
	CONVERSION UNITS	xi
	LIST OF TERMS	xii
	ACKNOWLEDGEMENTS	xiii
	ABSTRACT	xiv
	RESUME	xv
	SUMMARY	xvii
1.0	INTRODUCTION	1
2.0	COMMUNITY ASSESSMENTS - INITIAL INVESTIGATIONS	3
3.0	DIESEL HEAT RECOVERY AND SUPPLY APPLICATIONS	9
3.1	General Application of the technology	9
3.2	Assessment of Diesel Heat Supply in Big Trout Lake	16
3.2.1	Design of Diesel Heat Recovery and Utilization System	17
3.2.2	Economic Assessment of Heat Supply	22
3.2.3	Project Implementation	29
3.3	Assessment of Diesel Heat Supply to MTC's Airport Facilities in Sandy Lake	29
3.3.1	Design of Diesel Heat Recovery and Utilization Systems	31
3.3.2	Economic Assessment of Heat Supply	34
3.3.3	Project Implementation	37
3.4	Assessment of Diesel Heat Supply to Sandy Lake School	40
3.4.1	Design of Diesel Heat Recovery and Utilization Systems	42
3.4.2	Economic Assessment of Heat Supply	45
3.4.3	Project Implementation	53

4.0 WOOD BASED ELECTRICITY GENERATION 54

4.1 Assessment of the Technology for Wood Use for Electricity Generation 54
4.2 Assessment of Wood Use for Electricity Generation in Sandy Lake 61
4.2.1 Forest Resources 61
4.2.2 Collection System 63
4.2.3 Environmental Effects 66
4.2.4 Social Impacts 69

4.2.5 Wood Gasifier/Modified Diesel Engine Generator Assessment 70
4.2.5.1 Project Implementation 77
4.2.6 Wood Boiler/Steam Engine Generator 77
4.2.6.1 Project Implementation 87
4.2.7 Wood Boiler/Steam Turbine Generator Assessment 87
4.2.7.1 Project Implementation 94

5.0 CONCLUSIONS 95

6.0 RECOMMENDATIONS 96

APPENDICES

A Wood Resource and Potential Diesel Heat Recovery and Supply Assessment 97
B Economic Data 173

BIBLIOGRAPHY 175

LIST OF CONTACTS 180

LIST OF TABLES

Table Number	Title	Page Number
1.	Community Data	5
2.	15 Year Life Cycle Present Worth Project Cost Big Trout Lake Diesel Heat Supply	26
3.	15 Year Life Cycle Present Worth Project Cost Sandy Lake Diesel Heat Supply to MTC Airport Facilities	37
4.	15 Year Life Cycle Present Worth Project Cost Sandy Lake School Diesel Heat Supply	48
5.	1985 Capital Cost Wood Gasifier/Dual Fuel Diesel Unit	72
6.	1985 O&M Cost Comparison Wood Gasifier/Dual Fuel Unit Versus Diesel Unit	74
7.	Annual 1985 Fuel Cost Comparison Wood Gasifier/Dual Fuel Unit Versus Diesel Unit	75
8.	15 Year Life Cycle Present Worth Project Cost Wood Gasifier/Dual Fuel Unit Generation	76
9.	System Operating Characteristics Wood Boiler/Steam Engine Systems	81
10.	Capital Cost Wood Boiler/Steam Engine Alternative	82
11.	1985 O&M Cost Comparison Wood Boiler/Steam Engine Unit Versus Diesel Unit	83
12.	Wood Fuel Quantities and Costs Wood Boiler/Steam Engine Cycle	84
13.	15 Year Life Cycle Present Worth Project Cost Wood Boiler/Steam Engine Generation New Uniflow Engine Alternative	85
14.	15 Year Life Cycle Present Worth Project Cost Wood Boiler/Steam Engine Generation Used Counterflow Engine Alternative	86
15.	System Operating Characteristics Wood Boiler/Steam Turbine System	88

Table Number	Title	Page Number
16.	Capital Costs Wood Boiler/Steam Turbine Alternative	90
17.	1985 O&M Cost Comparison Wood Boiler/Steam Turbine Unit Versus Diesel Unit	91
18.	Wood Fuel Quantities and Costs Wood Boiler/Steam Turbine Cycle	92
19.	15 Year Life Cycle Present Worth Project Cost Wood Boiler/Steam Turbine Generation	93

LIST OF FIGURES

Figure Number	Title	Page Number
1.	Ontario Remote Communities	2
2.	Locations of Selected Remote Communities	4
3.	Forest Fires in the Pikangikum Area	7
4.	Heat Balance For a Typical Turbo Charged Diesel Engine	10
5.	Typical Hot Water Heating for Boiler Diesel Heat Recovery	12
6.	Alternative Conversions for Hot Air System	13
7.	Heat Emission Versus Flow Hot Water Heating Coil	15
8.	Change in Heat Emission With a Change in Water Temperature	15
9.	Big Trout Lake Pipeline Location Hot Water Delivery and Return	18
10.	Waste Heat Transport and Distribution System Big Trout Lake - Bell Canada	19
11.	Trenching Detail	21
12.	Diesel Jacket Water Heat Recovery and Supply to Bell Canada Remote Site Staff Housing Facility - Cumulative Present Worth Project Cost	27
13.	Diesel Jacket Water Heat Recovery and Supply to Bell Canada Remote Site Staff Housing Project Cost - Cumulative Present Worth Project Cost - Alternate Scenerio	28
14.	Sandy Lake MTC Facilities	32
15.	Waste Heat Transport and Distribution System Sandy Lake MTC Airport Application	33
16.	Diesel Jacket Water Heat Recovery and Supply to MTC Bunkhouse and Garage Facility, Sandy Lake - Cumulative Present Worth Project Cost	39

Figure Number	Title	Page Number
17.	Sandy Lake School Site Layout	41
18.	Sandy Lake School Pipeline Location - Hot Water Delivery and Return	43
19.	Waste Heat Transport and Distribution System Sandy Lake School Application	44
20.	Diesel Jacket Water Heat Recovery and Supply to Sandy Lake School - Cumulative Present Worth Project Cost	49
21.	Diesel Jacket Water Heat Recovery and Supply to Sandy Lake School - Cumulative Present Worth Project Cost - Alternate Scenerios One Furnace Room Case	50
22.	Diesel Jacket Water Heat Recovery and Supply to Sandy Lake School - Cumulative Present Worth Project Cost - Alternate Scenerios Two Furnace Room Case	51
23.	Diesel Jacket Water Heat Recovery and Supply to Sandy Lake School - Effect of Transport Distance on Costs	52
24.	Typical Wood Boiler/Steam Turbine Generator Arrangement	55
25.	Typical Fire Tube Package Wood Boiler	56
26.	Typical Water Tube Package Wood Boiler	56
27.	Typical Wood Boiler/Steam Engine Generator Arrangement	58
28.	Typical Counterflow Steam Engine Cylinder	59
29.	Typical Uniflow Cylinder with Optional Atmospheric Exhaust Ports	59
30.	Forest Wood Resources - Sandy Lake	64
31.	Cost of Wood Fuel Verses Quantity Harvested	65
32.	Labour Requirements Versus Wood Fuel Harvest	67

Figure Number	Title	Page Number
33.	Sandy Lake - Electricity Generation Using Wood Gasification in Conjunction with a Dual Fuel Modified Diesel Engine	71
34.	Electricity Generating Using Wood Fuelled Steam Boilers and Condensing Steam Engine - Sandy Lake	80
35.	Electricity Generation Using Wood Fuelled Steam Boilers and Condensing Steam Turbines - Sandy Lake	89

LIST OF ABBREVIATIONS

a - Annum
ac - Acre
BHP - Brake Horse Power
BTU - British Thermal Unit
C - Celsius
cm - Centimetre
CR - Control Relay
CV - Control Valve
F - Fahrenheit
FC - Flow Control
FI - Flow Indicator
ft - Feet
h, hr - Hour
ha - Hectare
HP - Horsepower
IGPM - Imperial Gallons Per Minute
in - Inch
J - Joule
JA - January
kg - Kilogram
kJ - Kilojoule
km - Kilometre
kPa - Kilo Pascal
kW - Kilowatt
kWh - Kilowatt Hour
L - Litres
lb - Pound
LCPW - Life Cycle Present Worth
m - Metre
mi - mile
mm - Millimetre
MTC - Ministry of Transportation and Communications
MV - Motorized Valves
NTS - Not to Scale
OD - Outside Diameter
ODMg - Oven Dry Megagram
OH - Ontario Hydro
O&M - Operating and Maintenance
P - Pressure
P1 - Pump 1
PSI - Pounds Per Square Inch
psig - Pounds Per Square Inch Gauge
PW - Present Worth
s - Second
TE - Temperature Element
TS - Temperature Switch

CONVERSION UNITS

To Convert From	To	Multiply By
centimetres (cm)	inches (in)	0.394
cords	cubic feet (ft^3) of solid wood	85.000
degree-days (°C)	degree-days (°F)	1.800
hectares (ha)	acres	2.471
$J/(h.m^2.°C/m)$	$BTU/(hr.ft^2.°F/in)$	0.0138
kilometres (km)	miles (mi)	0.621
kg/h	lb/hr	2.205
kilojoules (kJ)	British Thermal Units (BTU)	0.948
kPa	inches H_2O	4.015
kPa	Psi	0.145
kW	Horsepower	1.341
litres (L)	Imperial Gallons	0.220
L/S	IGPM	13.203
metres (m)	feet (ft)	3.280
metres, cubed (m^3)	cords	0.415
ODMg	cords	1.102
ODMg/hectare	cords/acre	0.446
°C	°F	(1.8°C+32)

LIST OF TERMS

1.	Cord	A unit of wood, usually a pile 4 ft x 4 ft x 8 ft, containing approximately 85 ft^3 of solid wood.
2.	Discount Rate	The effective cost of money to an individual or corporation.
3.	Escalation	The time related rate of increase in the cost of goods or services, including the effect of general inflation.
4.	Labour Intensive Harvesting	The harvesting of timber maximizing the role of efforts, at the cost of overall productivity.
5.	Life Cycle Present Worth Cost	The cost over a defined life period of an item related to a defined point in time by discount rate factors. Useful in comparing alternatives on a common basis.
6.	Mechanized Harvesting	The harvesting of wood resources using mobile machinery such as skidders and mobile chippers to enhance harvest productivity.
7.	Retirement Value	The residual value of a piece of equipment at the end of a defined life cycle period.
8.	Station Service	The electrical energy requirements of a process to produce a net supply of electricity to external users.

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ABSTRACT

The electrical needs of remote communities in Ontario's north are supplied by oil fuelled diesel generators. The production cost of electricity is substantially higher than that for the bulk system due to the high cost of fuel and maintenance. In order to reduce these and other high energy costs in remote communities, the Federal Government in 1982 instituted the Remote Community Demonstration Program (RCDP) to encourage the study and implementation of energy conservation and oil substitution where economic.

This report documents the results of a study jointly funded by the RCDP Program and Ontario Hydro which focuses on alternative generation technologies, particularly those using wood fuel, and diesel engine heat recovery and use. Four communities were considered in a preliminary review: Big Trout Lake, Sandy Lake, Pikangikum and Armstrong. Big Trout Lake and Sandy Lake were selected for further study.

In Big Trout Lake, diesel heat recovery and supply to a Bell Canada facility was examined. The economics appear favourable provided a payback of approximately ten years is acceptable.

In Sandy Lake, three situations were examined: diesel heat supply to the Ministry of Transportation and Communication (MTC) airport facility, diesel heat supply to the Sandy Lake school, and wood based electricity generation. Favourable economics may be possible for heat supply to the MTC airport facilities if a 15 year payback is acceptable. Heat supply to the Sandy Lake school and wood based electricity generation do not appear from an operator's point of view to be economical.

As a result of the investigations and findings of this study, the following recommendations are put forth for those preparing policy and making program decisions:

1. Until the issues associated with wood use for electricity generation in remote communities are resolved, wood should not be considered by Ontario Hydro as a fuel for electricity generation in remote communities such as Sandy Lake not having large quantities of inexpensive wood fuel, easy access, and trained operators.

2. Operators of engine generator facilities should be encouraged to participate in diesel heat recovery and supply projects, taking into account transport distances, diesel heat availability and incremental operating expenses.

3. Ontario Hydro's Marketing Branch should continue their development of a comprehensive policy on remote site diesel heat sales, allowing sufficient flexibility to accommodate site specific circumstances.

4. Current and future remote site community facilities and community electrification planning should take into account the possibility of future diesel generator heat supply.

5. Discussions should be held between Ontario Hydro's Regional Marketing and Operations representatives and those for Bell Canada's and MTC's northern operations regarding the possibility of diesel heat supply in Big Trout Lake (Bell Canada), Sandy Lake (MTC) and Pikangikum (MTC).

ÉTUDE SUR LES AUTRES MODES DE PRODUCTION D'ÉNERGIE ET D'UTILISATION DE LA CHALEUR RÉSIDUAIRE DANS LES COLLECTIVITÉS ÉLOIGNÉES D'ONTARIO

Résumé

Les besoins en électricité des collectivités éloignées du Nord de l'Ontario sont comblés à l'aide de génératrices alimentées au carburant diesel. Le coût de l'électricité est de beaucoup supérieur à celui que doivent assumer les clients des réseaux, par suite du coût élevé du carburant et de l'entretien. Afin de réduire ces coûts et de stimuler la croissance dans ces collectivités, le gouvernement fédéral a institué en 1982 le Programme de démonstration dans les collectivités éloignées (PDCE) en vue d'encourager l'étude et l'application de mesures d'économie et de remplacement de l'énergie, lorsque cette solution est jugée économique.

Le présent rapport permet de relever les résultats de la première partie d'une étude financée conjointement dans le cadre du PDCE et par l'Ontario Hydro; il met l'accent sur les techniques relatives aux autres modes de production d'énergie, notamment celles qui font appel au bois comme combustible, et à l'utilisation de la chaleur résiduaire. Le potentiel qu'offrent les quatre collectivités désignées a été étudié dans la première partie de l'étude, soit Big Trout Lake, Sandy Lake, Pikangikum et Armstrong. Les collectivités Big Trout Lake et Sandy Lake ont été choisies pour être étudiées plus en détail.

La récupération de la chaleur d'une génératrice alimentée au carburant diesel et l'approvisionnement d'un bâtiment de Bell Canada ont été examinés à Big Trout Lake. Les économies qui pourraient être réalisées semblent acceptables pourvu que le seuil de rentabilité soit d'environ 10 ans.

Trois situations ont été examinées à Sandy Lake soient: l'approvisionnement en chaleur résiduaire des installations aéroportuaires du ministère des Transports et des Communications, l'approvisionnement de l'école Sandy Lake en chaleur résiduaire et la production d'électricité à partir du bois. L'étude révèle que l'approvisionnement en chaleur résiduaire des installations aéroportuaires du ministère des Transports et des Communications permettrait de réaliser des économies acceptables si le seuil de rentabilité est de 15 ans. L'approvisionnement de l'école Sandy Lake en chaleur résiduaire ainsi que la production d'électricité à partir du bois ne semblent pas être rentables selon le point de vue des opérateurs.

Suite aux résultats des enquêtes et aux conclusions tirées de la présente étude, les recommandations qui suivent ont été formulées pour ceux qui élaborent la politique et pour ceux qui ont à prendre des décisions au sujet du programme:

1. Jusqu'à ce que les questions reliées à l'utilisation du bois pour la production d'électricité dans les collectivités éloignées ne soient pas résolues, il a été recommandé à l'Ontario Hydro de ne pas utiliser le bois comme source d'énergie électrique dans les collectivités éloignées telles que Sandy Lake, qui ne disposent pas de quantité suffisante de bois disponible à bon prix, ne sont pas d'accès facile et où le personnel n'a pas reçu de formation dans le domaine.

2. Les opérateurs de machine des services d'utilité devraient être encouragés à participer aux projets ayant trait à la récupération de la chaleur et à l'approvisionnement en chaleur résiduaire des centrales diesel en tenant compte des distances que le fluide caloporteur devrait franchir, de la disponibilité de la chaleur résiduaire d'une génératrice alimentée au carburant diesel et de l'augmentation des dépenses de fonctionnement.

3. La division de la commercialisation de l'Ontario Hydro devrait continuer à élaborer une politique compréhensive pour la vente de chaleur résiduaire des génératrices alimentées au carburant diesel aux collectivités éloignées. Cette politique devrait être assez flexible pour accommoder les circontances spécifiques aux sites.

4. La possibilité de récupérer la chaleur résiduaire des centrales diesel devrait dorénavant être prise en considération lors des travaux de planification des bâtiments dans les collectivités éloignées et de la planification des installations de production d'énergie électrique.

5. Les représentants du Bureau régional de la commercialisation et des opérations de l'Ontario Hydro devraient entreprendre des pourparlers avec ceux de Bell Canada et du ministère des Transports et des Communications de l'Ontario au sujet de l'approvisionnement en chaleur résiduaire de leurs installations, situées respectivement à Big Trout Lake, à Sandy Lake et à Pikangikum.

ALTERNATIVE GENERATION AND DIESEL HEAT RECOVERY IN REMOTE ONTARIO COMMUNITIES

SUMMARY

INTRODUCTION

Remote communities are those whose location and/or size have resulted in some degree of isolation. Many of the services and facilities taken for granted in more populated southern communities are limited or non-existent. The supply of electricity is one of those services.

Connection to a large power grid from which relatively inexpensive, reliably supplied electricity can be drawn is infeasible in remote communities. They commonly rely for electricity on small central diesel generating plants, or in many cases have no supply system at all. Where central systems do exist, the individual user's power allowance is often limited by either a low capacity service entrance or by the cost of electrical power itself.

In Ontario, there are over 41 communities; the minority having community electricity supply systems. Ontario Hydro operates and maintains this service in sixteen communities.

The cost of electricity production in remote Ontario Hydro supplied communities is very high relative to that produced for the power grid, particularly in air access only communities. In 1984, a production cost of $0.41/kWh is likely typical. In rail communities such as Armstrong the cost is somewhat lower. The cost of diesel fuel (0.63$/L-1983) which must be flown in and the cost of maintenance provided by regional personnel are major cost components.

Residents in Ontario Hydro supplied communities pay a subsidized rate ($0.0925/kWh-1984) for limited 20 amp service, equal to Ontario Hydro rural rates. The subsidy is provided from the Bulk System sales. Rates for commercial and institutional facilities are much higher. Government Services are charged the full production cost. Non-government businesses receive a one-third discount, subsidized by the rural retail customers.

In 1983, Ontario Hydro's Power Equipment Department undertook to investigate the feasibility of wood based, remote site generation systems, and diesel heat recovery and supply systems. Federal Government Remote Community Demonstration Program (RCDP) co-funding was sought and approved.

Initial investigations reviewed the general layout, potential diesel heat recovery applications and forest resource potential in four communities: Sandy Lake, Big Trout Lake, Pikangikum and Armstrong. Appendix A presents the results of these investigations.

COMMUNITY ASSESSMENTS

Wood Fuelled Electricity Generation

The study of wood based systems showed that more detailed study should be limited to the communities of Armstrong and Sandy Lake. Pikangikum initially appeared to have good local resources, but had been the site of significant forest fire activity several years earlier. The local inventory was decimated and the fire killed wood had rotted significantly. Big Trout Lake was found to have significant wood resources, but those areas which would have had to provide a large part of the wood supply for electricity generation were unavailable. The band identified those areas as for band members use only.

After some review with Energy Mines and Resources Canada personnel, it was decided to evaluate a wood fuelled electricity generating system in Sandy Lake. The Sandy Lake wood scheme was selected over that of Armstrong because of similar work likely to be done by others for that location.It was seen as more valuable at this time to consider a truly remote community.

Diesel Heat Recovery and Supply Applications

Big Trout Lake and Sandy Lake were selected as offering the best diesel heat recovery and supply opportunities. In Big Trout Lake, Bell Canada operates a large remote site staff residence only about 180 m from the Ontario Hydro diesel generator station. In Sandy Lake, the Ontario Ministry of Transportation and Communication has airport facilities, a bunkhouse and garage, only twenty metres from the Ontario Hydro diesel station. The Sandy Lake school, although 1200 metres away, was also examined.

Potential diesel heat recovery and supply applications in Pikangikum and Armstrong are either similar to those in Big Trout Lake or Sandy Lake. In Pikangikum, the best opportunity is the MTC airport facilities. The other major oil heated facility is the school which is even further from the diesel station than in Sandy Lake. In Armstrong, the diesel station is quite isolated. The closest facility is the CN bunkhouse and station house. These are quite large heat users, but the distance from the diesels, the route of the pipline under the tracks and in the case of the bunkhouse the complexity of a retrofit make such an installation infeasible. The community school and MNR office are even more distant.

In summary, as a result of the initial review, more detailed study was undertaken of three diesel heat supply situations and one wood based electricity generation option. These are summarized below in Table S1.

TABLE S1

Summary of Remote Site Energy Options Assessed

Option	Product	Remote Site	Customer	Energy Supply	Electricity Fuel Feedstock
1	Diesel Heat	Big Trout Lake	Bell Canada	Heat-21,000 to 36,600L oil equiv.	Diesel Oil
2	Diesel Heat	Sandy Lake	MTC Airport	Heat-15,000 to 20,500L oil equiv.	Diesel Oil
3	Diesel Heat	Sandy Lake	School-supply to one or two furnace rooms	Heat-33,000 to 82,500L oil equiv.	Diesel Oil
4	Electricity	Sandy Lake	Community	Electricity-850,000 to 1,250,000 kWh	Wood

From the Energy Supply column in Table S1, considerable variation in energy supply requirements is evident. This is due to uncertainty about the actual heating energy requirements, the percentage of the heat requirement which could be supplied by a diesel heat recovery system, and future electrical load growth. Several cases were examined for each option to determine the effects of various assumptions.

Diesel Heat Recovery and Supply Economic Feasibility

For the diesel heat recovery and supply applications, the economic results in Table S2 were determined.

TABLE S2

Economic Assessment
Diesel Heat Recovery and Supply

			Sandy Lake School	
	Big Trout Lake Bell Canada	Sandy Lake MTC Airport	1 Furnace Room Supply	2 Furnace Room Supply
Capital Cost (1985$)	142,500	106,000	567,300	597,300
15 Year Life Cycle Present Worth (1985$) Operating and Maintenance Cost	65,300	42,400	145,200	237,400
15 Year Life Cycle Present Worth (1985$) Replacement Fuel Cost	-285,500 to -164,700	-159,400 to -119,500	-385,500 to -258,500	-642,600 to -431,200
Total 15 Year Life Cycle Present Worth (1985$) Project Cost	-77,700 to +43,100	-11,000 to +28,900	327,000 to 454,000	192,100 to 403,500
Present Worth Payback Period	Minimum 10 Years	Minimum 13 Years	--	--

A positive total indicates that the project costs more in present worth terms than remaining on oil. A negative total indicates the oil substitution project is feasible if a 15 year payback at rates of return (discount rates) used in this study are acceptable.

There are potential savings to be made in the Bell Canada Big Trout Lake case and the Sandy Lake MTC case. The Sandy Lake School case is infeasible. Figure 23 on page 52 in Section 3.4.2 of the body of the report shows the effect one way transport distance would have had on the school case results.

The Bell Canada case appears most feasible. The worst case where the project would lose money saves only 43 percent of the heating oil and is considered pessimistic. The major issues to be resolved before a project could be implemented are:

(a) The development of a policy on pricing and capital cost sharing for remote site diesel heat energy sales.

(b) Uncertainty over the likely electrical load pattern and diesel heat availability in Big Trout Lake upon connection of outlining mainland community areas to the system.

(c) Reduced diesel heat availability should an Ontario Hydro residence facility heated by diesel engine heat be installed.

(d) Acceptable payback criteria for public, institutional and private participants.

The Sandy Lake MTC airport facilities case is economically somewhat less favourable, but there are also some positive factors. Significant savings in the capital cost may be possible. Also, although the fuel requirement is uncertain, heat replacement is most likely almost 100 percent. Thus a net 15 year life cycle present worth project savings is expected. Before implementation is considered, the following issues would have to be resolved:

(a) The development of an acceptable heat pricing policy.

(b) The determination of the heating fuel quantities likely to be replaced in the future, taking into account energy management planning by the Ministry of Transportation and Communication.

Upon resolution, a re-evaluation could provide both Ontario Hydro's Regional staff and those of the MTC with the details necessary to decide whether to make a committment to the project. Less difficulty would be expected with payback requirements in this case since a longer payback would be more acceptable to a government agency than to private industry.

Wood Fuelled Electricity Generation - Economic Feasibility

For electricity generation from wood fuel, the alternatives illustrated in Figure S1 are examined.

FIGURE S1

Electricity Generation From Wood Alternatives

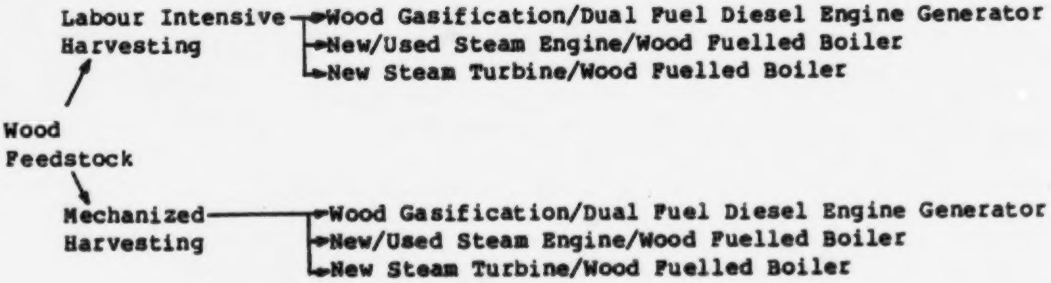

Labour Intensive Harvesting
Wood Gasification/Dual Fuel Diesel Engine Generator
New/Used Steam Engine/Wood Fuelled Boiler
New Steam Turbine/Wood Fuelled Boiler
Wood Feedstock
Mechanized Harvesting
Wood Gasification/Dual Fuel Diesel Engine Generator
New/Used Steam Engine/Wood Fuelled Boiler
New Steam Turbine/Wood Fuelled Boiler

Table S3 presents a summary of the economics from an operator's point of view of wood fuelled electricity generation, for the case of mechanized wood harvesting, with wood collected for electricity generation only. Costs would be higher for labour intensive harvesting, but slightly lower if wood for electricity generation and community heating were collected simultaneously.

TABLE S3

15 Year Life Cycle Present Worth Wood Fuelled Electricity Generation Costs

Cost Component	Wood Gasification	New Steam Engine/ Wood Boiler	Used Steam Engine/ Wood Boiler	New Steam Turbine/Wood Boiler
Capital Cost	$1,750,000	$1,895,000	$1,740,000	$1,825,000
15 Year Life Cycle Present Worth (1985$) Incremental Operating and Maintenance Cost	$1,023,000	$1,906,000	$1,906,000	$2,020,000
15 Year Life Cycle Present Worth (1985$) Incremental Fuel Cost	-$1,312,000	-$ 32,000	$ 638,000	$ 227,000
15 Year Total Life Cycle Present Worth (1985$) Project Cost	$1,461,000	$3,769,000	$4,284,000	$4,072,000

Based on these costs, wood based electricity generation is obviously infeasible in Sandy Lake and in other communities with similar circumstances from an operator's point of view. Sites having easy access and readily available low cost wood or wood waste may have different results. If the operation of the plant could be a part of a larger commercial operation, operating costs might also be reduced significantly.

Although the major issue to be resolved before implementation could be considered, economics is not the only issue. Others include:

(a) Band concerns over community wood availability, and woodlands harvesting's effects on trapping and hunting.

(b) Uncertainty over forest regrowth potential.

(c) Ontario Government Parks and Forestry policy.

(d) Regional Ontario Hydro operating personnel concern over the reliability, availability and maintenance costs of wood based equipment.

(e) Equitable distribution within the community of positive socio-economic benefits due to wood fuelled operation.

The following paragraphs briefly described these and the economic and technical factors affecting wood based generation.

Wood fuel costs are a major economic factor of wood based systems in Sandy Lake. In the labour intensive case, the relatively low productivity of harvesting and transporting result in costs of over $200/OD Mg ($190/cord). In the mechanized case, higher productivity is achieved, but at a significant cost in capital equipment which is under-utilized. Mechanized harvesting costs of over $90/ODMg ($80/cord) would be expected. In both cases, wood cost would vary somewhat inversely with the quantity required.

In conjunction with the high fuel cost, the low process efficiencies of the various wood conversion systems leads to very high fuel costs. Wood gasification/dual fuel diesel engine processes are claimed to have the highest full load efficiency, approximately 16 to 17 percent (wood on-site to electricity). This results in full load fuel costs of 12.7¢/kWh (mechanized harvesting) to 27.5¢/kWh (labour intensive harvesting) versus approximately 25.8¢/kWh for diesel fuelled generation in 1985. Operating experience to date would lead one to view the gasifier fuel costs as optimistic. Wood-fuelled steam cycle process efficiencies are much lower than the gasification process; 5.4 to 7.0 percent, not including 16 percent station service energy requirements. At these efficiencies full load fuelling costs are 25.4-33.0¢/kWh (mechanized harvestings) to 60.4-78.3¢/kWh (labour intensive harvesting). This is more than the 1985 diesel fuelling cost/kWh. Although wood fuel costs would escalate at a lower rate than diesel fuel, and may be cheaper in life cycle present worth terms, the saving will not likely be sufficient to offset additional operating and capital costs.

The capital costs of the wood based conversion systems in this report are typically $1,750,000 (1985$). This high capital cost relative to the unit size and to diesel units is a difficult issue to overcome, particularly in light of the limited fuel cost savings and the additional operating costs.

Additional operating labour requirements are a major economic factor. Diesel plants operating in remote communities require only intermittent operator attention. Wood based processes will require either full time operating personnel or greatly increased attention at the very least. The operating labour costs in Table S3 reflect the attention needed by these units.

Forest regrowth potential is a major concern and questionmark. Local community wood heating and wood fuelled electricity generation would require between 3600 and 5850 ODMg (3900 to 6450 cords) per year. This will require significant areas of wood (100 to 450 acres per year) to be cut each year based on existing stand volumes. To accommodate the long regrowth cycle in the north, harvesting will have to be undertaken further and further from the community.

In poor growth areas, soil conditions and growth rate could change significantly. In addition, the better growth areas may be unavailable as the community grows. Even in these better areas, the second rotation wood availability would be less than currently standing and the areas harvested would have to be larger.

In addition to the band's concern over the quantity of wood needed for electricity generation, a concern over the effects on Sandy Lake trap lines operators and those of neighbouring communities is evident. Assurances would have to be provided that no adverse affects would be involved or compensation provided. This may prove infeasible due to the uncertainties and costs invovled.

Regional Ontario Hydro operating personnel would not look favourably upon a system which would complicate their future plans. The trend is currently toward more automatic operation, less operator involvement. It is hoped that this will minimize the number of operator errors currently encountered and improve unit efficiency. A wood based system would reverse this trend and require highly trained operators, special equipment, and specially trained maintenance and support staff. A high probability of success and significant gains would have to be demonstrated before such complicated systems would likely be well received. No operational interference with existing equipment systems would likely be tolerated.

A further issue to be addressed is the Ontario Government plans for wilderness and waterway parks. There are currently proposals in the West Patricia Land Use Plan to conserve some of the land in the vicinity of Sandy Lake. These plans plus a potential requirement for environmental assessments for non-community wood harvesting would seriously influence the cost and ability to harvest available wood. Clarification of the implications would be required before even an apparently economical project could be committed to.

A wood fuelled electricity generation project would have significant positive social benefits. Direct full and part-time employment would be created in both wood harvesting and at the power plant.

(a) Harvesting
- mechanized: 6 to 8 persons for 15 weeks per year
- labour intensive: 13 to 15 persons for 38 weeks per year

(b) Power Plant Operation - 2 to 6 persons full time employment.

In addition there would be some indirect employment creation likely and the potential for a community wood harvesting system. The equitable distribution of economic benefits would become an issue to be examined and resolved.

Overall, the following recommendations are put forth for those preparing policy and making program decisions:

(a) Until the issues identified with wood use for electricity generation in remote communities are examined and resolved, wood as a fuel for electricity generation should not be considered by Ontario Hydro in remote communities such as Sandy Lake, not having large quantities of inexpensive wood fuel, easy access and low cost trained operators.

(b) Operators of diesel facilities should be encouraged to participate in diesel heat recovery and supply projects, taking into account heat medium transport distances, diesel heat availability and incremental operating expenses.

(c) Ontario Hydro's Marketing Branch should continue their development of a comprehensive policy on remote site diesel heat sales, allowing sufficient flexibility to accommodate site specific circumstances.

(d) Current and future remote site community facilities and community electrification planning should take into account the possibility of future diesel generator heat supply.

(e) Discussions should be held between Ontario Hydro's Regional Marketing and Operations representatives and those for Bell Canada's and MTC's northern operations regarding the possibility of diesel heat supply in Big Trout Lake (Bell Canada), Sandy Lake (MTC) and Pikangikum (MTC).

Alternative Generation and Diesel Heat Recovery
In Remote Communities

1.0 INTRODUCTION

Ontario Hydro currently provides a central diesel generator based electricity production and distribution service in 16 remote and rail communities in Northern Ontario (Figure 1). By 1987, approximately nine more communities may be supplied. The cost of the production and distribution of electricity is much higher than for that produced for the power grid. The high cost of diesel fuel and maintenance equipment and personnel are the major contributors.

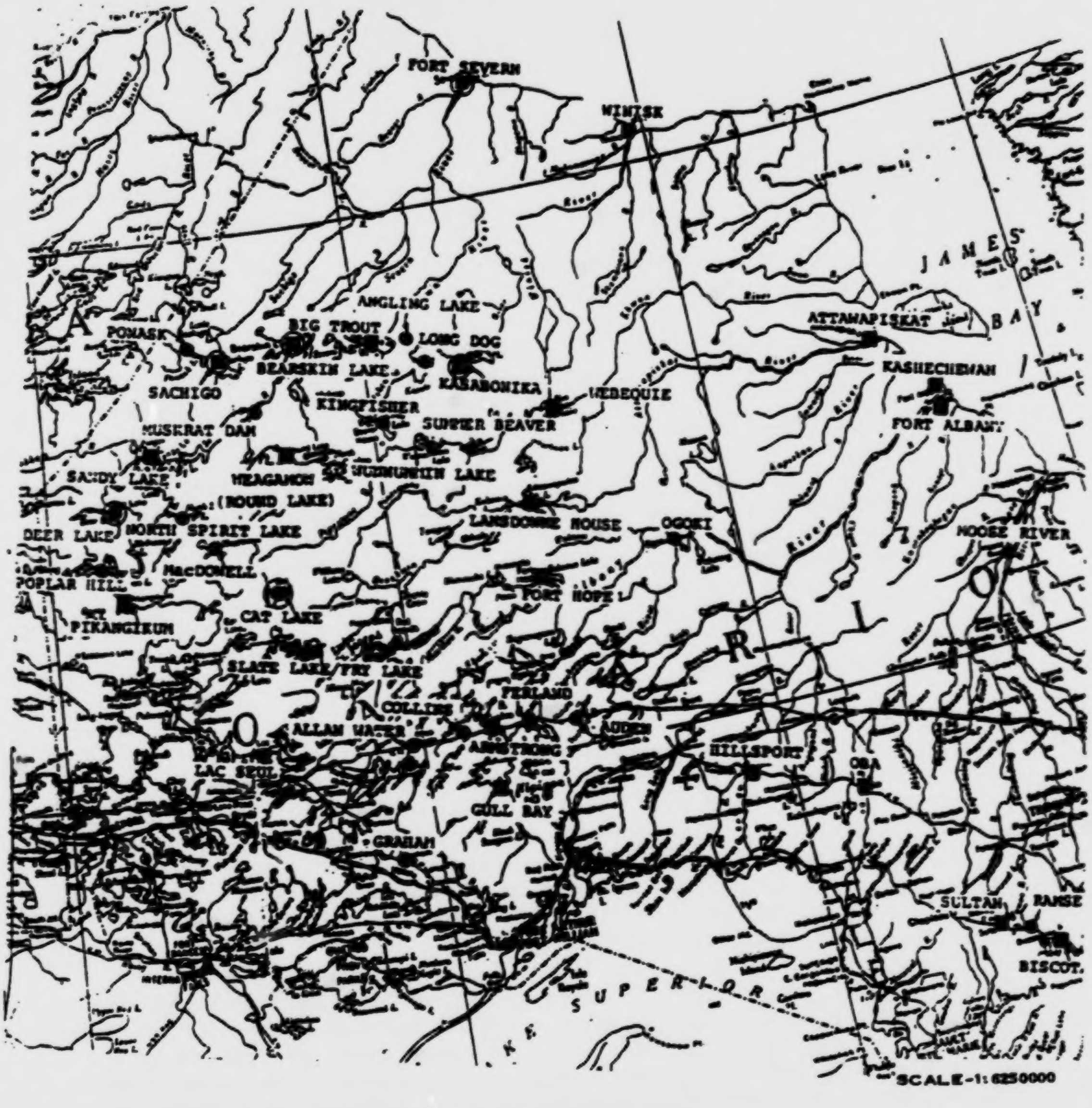
Alternative energy production using wood, wind, small hydraulic and solar energy as well as any means of improving energy efficiencies and costs are of particular interest to remote communities and the government agencies responsible for the servicing of these communities.

Ontario Hydro's Alternative Energy Systems Section of the Power Equipment Department, formerly the Energy Studies Department has been actively involved in looking at alternatives to diesel generation for remote communities since 1978. Several reports have been published on the application of alternative energies in these situations. Several pilot demonstration projects have been in operation; a wind-diesel pilot plant in Sudbury, a photo-voltaic cell demonstration installation at the Kortwright Conservation Area and near Atikokan.

In 1982, studies by the Federal and Ontario provincial governments[10, 11, 15] indicated that wood based alternatives might be considered economical for remote site generation. It was felt by personnel in the then Energy Studies Department that a somewhat more specific assessment of the potential in specific communities was needed, since our own preliminary studies had previously indicated that wood based systems would not be economical. Installations where heat recovery could be used to improve the overall system economics and energy efficiency were of particular interest.

In January 1983, the Energy Studies Department applied under the Federal Government's Remote Community Demonstration Program (RCDP) for co-funding of a study to examine the feasibility of wood based generation systems, and electricity generation heat recovery and supply. The RCDP program was established by the Federal Government in 1982. A two phase, seven year program, its aims were to establish the feasibility of alternative energies and improved energy efficiency of systems in remote communities in Canada and to provide funding for practical demonstration projects.

FIGURE 1
ONTARIO REMOTE COMMUNITIES



● REMOTE COMMUNITIES HAVING NO CENTRAL ELECTRICITY GENERATION FACILITIES OR SERVICED BY LOCAL NON-ONTARIO HYDRO DIESEL GENERATORS

■ REMOTE COMMUNITIES SERVICED BY ONTARIO HYDRO DIESEL GENERATORS

◙ REMOTE COMMUNITIES TO BE SERVICED BY ONTARIO HYDRO IN 1984– 1985

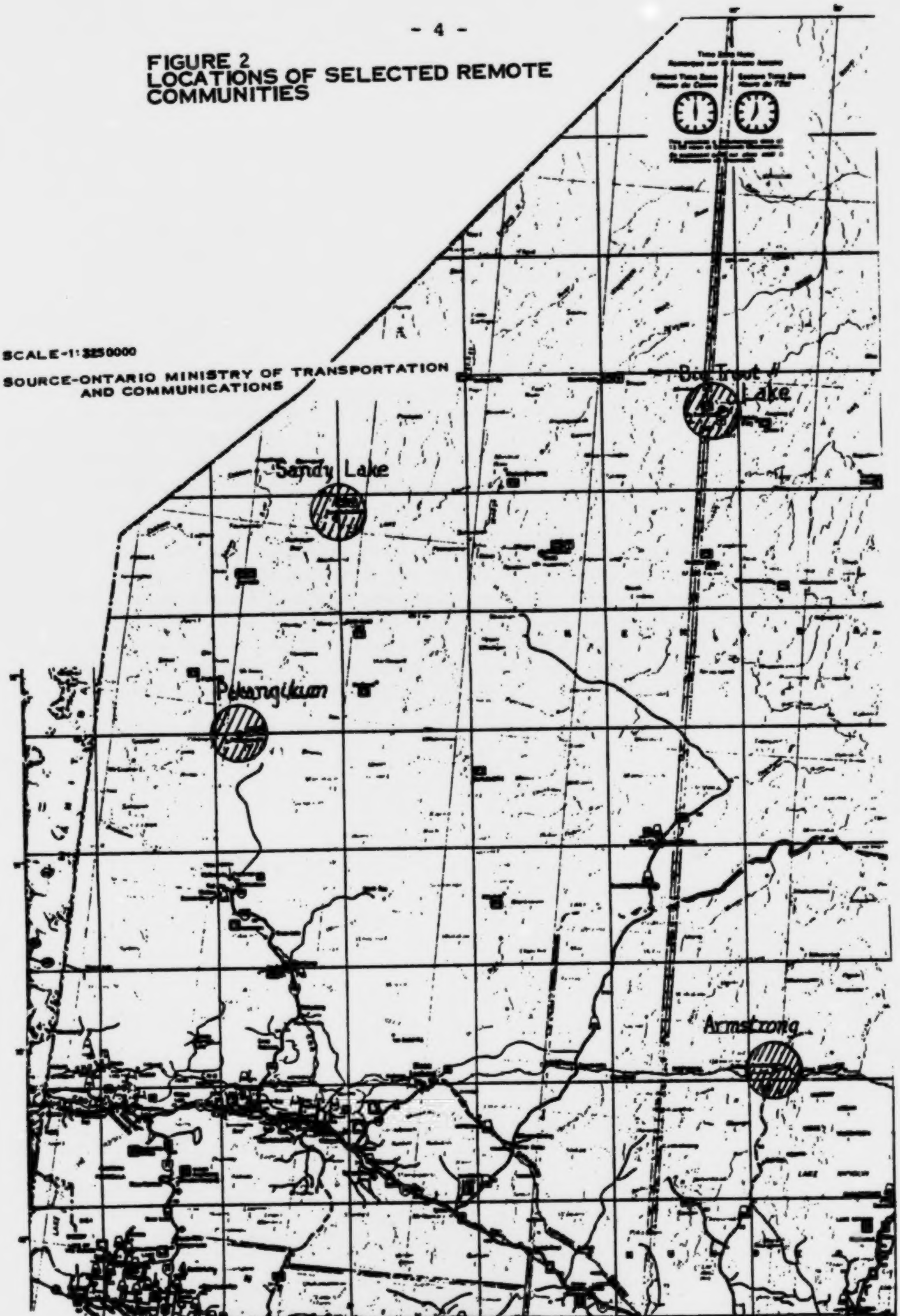
◉ REMOTE COMMUNITIES TO BE SERVICED BY ONTARIO HYDRO IN 1985–1986

The Ontario Hydro proposal selected four remote communities appearing to have potential wood fuelled generation and heat recovery and supply applications: Sandy Lake, Big Trout Lake, Pikangikum, and Armstrong (Figure 2). Their selection was based on preliminary information presented in reports by Middleton Associates and Ralph Hedlin Associates[10, 11]. The major criteria used in their selection was their population, community facilities, diesel fuel prices, potential wood availability and data availability.

Initial investigations reviewed their potential for heat recovery and supply from an electricity generating application and the potential for a wood based generation alternative. The results of this effort are documented in considerable detail in Appendix A. Background information on the community, its energy usage, available facilities, and available forest resources is also provided.

Two of the communities were selected for more detailed analysis and design: Big Trout Lake and Sandy Lake. In Big Trout Lake, diesel generator heat recovery and supply to the Bell Canada Remote Site Staff Housing facility was examined. In Sandy Lake, a wood based generation alternative and two diesel generator heat recovery and supply applications, diesel heat supply to the Ministry of Transportation and Communication's airport facilities, and to Sandy Lake school, were examined.

FIGURE 2
LOCATIONS OF SELECTED REMOTE COMMUNITIES



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SOURCE-ONTARIO MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

2.0 COMMUNITY ASSESSMENTS - INITIAL INVESTIGATIONS

Information available on the communities of Big Trout Lake, Sandy Lake, Pikangikum and Armstrong and collected from site visits and other sources, was compiled. Based on this information, the potential for wood based generation of electricity and diesel heat use applications was assessed for each community.

Community Data

Background community data for Big Trout Lake, Sandy Lake, Pikangikum and Armstrong was collected. Table 1 briefly summarizes this. More details and aerial photographs of the communities are provided in Appendix A.

Wood Resources

Wood resources were assessed using existing forest data and some preliminary aerial photograph interpretation. Some on-ground cruising provided additional information to this assessment and a perspective on local availability. Information from Indian band and local community leaders provided insight on the communities attitude toward use of local resources.

TABLE 1

Community Data

	Big Trout Lake	Sandy Lake	Pikangikum	Armstrong
Population - People	750	1400-1500	950	800
- Households	135	240	179	126
Location	53°N49'x 80°W53'	53°N10'x 93°W20'	51°N48'x 93°W59'	50°N18'x 89°W2'
Access - Road	Winter	Winter	Winter	All-Weather
- Rail	N	N	N	Y
- Air	Y	Y	Y	N
Tribal Council	Kayhanna	Pehtabun	Pehtabun	N/A
School	Gr 1-6	Gr 1-10	Gr 1-8	Gr 1-8
Nursing Station	Y	Y	Y	N
Mean Annual Temp	-3°C	-3°C	0.7°C	-1.1°C
Annual Degree Days	7800°C	7800°C	6333°C	6921°C
Electricity - Utility	OH	OH	OH	OH
- Gen Units	3x125kW	2x175,1x440kW	2x125,1x175kW	2x350kW
- 1982 Gen (kWh)	784,250	1,715,200	707,300	1,610,500
- Fuel Cost /L (1982)	0.56	0.54	0.44	0.27
- Fuel Consump (1982)	333,022 L	606,871	267,730	507,194
- Unit Eff	21.9%	26%	24.7%	29.6%

The wood resource assessment in the Armstrong area indicated that sufficient wood resources are available to support a local wood based generation scheme. Discussions with area timber licensees, the Ministry of Natural Resources and local contractors indicated that sufficient wood harvesting machinery and manpower would likely to be available over a significant time period to support a wood generation scheme of 200 kW+. Initially there was some concern over long term supplies, but recent communications with those involved indicate that this would not be a problem.

Wood delivered to a generating facility would cost between $50 and $80/OD Mg ($45 to $73/Cord). A significant part of this is transportation and harvesting costs. Additional costs such as road maintenance and overheads are also included. Relative to the other communities, the wood is inexpensive. Wood Waste is unavailable. No local processing facilities are located in the Armstrong area.

The cost of diesel fuel currently used to generate electricity in Armstrong is also low (28¢/L). The higher diesel fuel cost in more remote communities, 62¢/L, appears to offer more favourable substitution potential.

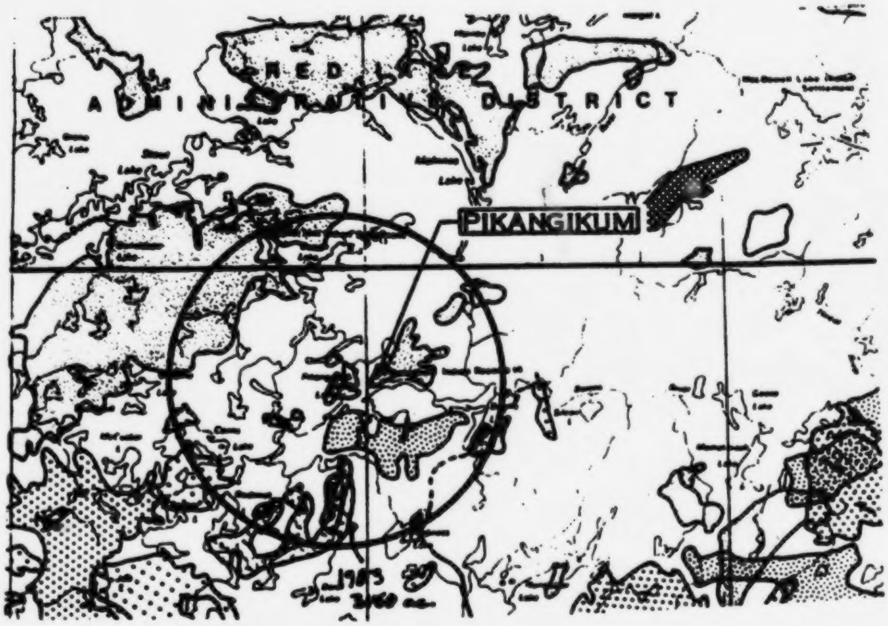
The assessment of wood resources in Big Trout Lake agreed with Middleton's earlier assessment. There appears to be enough annual growth to consider a wood based generation alternative. However, the band wish to reserve the best growth areas for local home heating use and future lumber uses. The remaining areas are in most cases very poor quality. Considerable uncertainty exists over the effects of harvesting in these areas on forest regrowth and the forest environment, i.e., soil degradation and water table levels. As a result of these factors, Big Trout Lake was dropped from further consideration of wood use for electricity generation.

Pikangikum was initially selected for an assessment of wood based generation because available Ontario Ministry of Natural Resources Forest Inventory Report data indicated good resources. Local fires have however decimated much of the area around the community (Figure 3). Areas outside those consumed are farther and of poorer quality. The local band would not look favourably upon a wood based generation system. No further work in this community was undertaken.

The assessment of forest resources in the Sandy Lake area identified significant quantities of available wood. Initially, much more wood was thought available than estimated at the time the interim report was published. It appears that the local resources could support a small base loaded wood fuelled generation facility, in addition to the local heating needs.

According to a Ministry of Natural Resources source a detailed assessment of forest potential would likely need to be undertaken. This might include an environmental assessment, with periodic updates. In view of some uncertainty on the part of the band, they too would need to be fully satisfied.

FIGURE 3
FOREST FIRES IN THE PIKANGIKUM AREA



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SOURCE-ONTARIO MINISTRY OF
NATURAL RESOURCES

LEGEND

░	1920 — 29
░	1930 — 39
▨	1940 — 49
▒	1950 — 59
□	1960 — 69
□	1970 — 79
■	1980
▨	1981

It is clear that any wood based scheme will require significant quantities of wood. That wood and the home heating wood individual villagers require will have to come from more distant sources with time and as the community grows. This will significantly increase costs, and may face objections from local and neighbouring community residents.

Diesel Heat Recovery and Supply Applications

With respect to diesel heat use, the distance between user and source, user size, and demand and supply timing are critical factors. In all four communities visited, an optimum combination of these factors was felt to be missing.

The closest community facilities were the MTC airport facilities in Sandy Lake and Pikangikum, the Bell Canada Remote Staff Residence in Big Trout Lake, and CN's facilities in Armstrong. The other potential heat users were the local schools, but these were all located a considerable distance from the existing generator sites. The Bell Canada remote site staff residence in Big Trout Lake appears the best existing opportunity. It has a relatively large heat demand and is relatively close compared to other large heat users.

The Sandy Lake Ministry of Transportation and Communication's airport facilities, a bunkhouse and garage, are the oil heated facilities closest to the diesel generators in any of the communities. Although small, in size and fuel consumption, they are within thirty metres of the existing diesel generator. Further, they are representative of several communities such as Pikangikum where the diesels are located at the airport.

The Sandy Lake school was considered for examination in Part II of the study because it represented a sizeable oil fuelled heat load at a considerable distance from the diesel heat sources. It was not expected however to be economical due to the distance from the generators, 1200 m. This is also the case in Pikangikum and many other communities.

Pikangikum's community facilities were not specifically considered. Those in Big Trout and Sandy Lake offered better and somewhat similar opportunities for study. In particular, the MTC results from Sandy Lake could be easily applied to Pikangikum.

No existing heating opportunities were identified in Armstrong. In all cases, the diesel generators were considered too far from the user, or the user's facilities too complicated. The results of the study in Sandy Lake and Big Trout Lake could, in a general manner, be applied.

Extensive studies of the potential for heating future facilities were not conducted. The lack of planning information, uncertainty over existing planning information, and the variety of alternative heating requirements, technologies and fuels, made such an examination infeasible. Local greenhouse food farming was briefly examined, but rejected for lack of market opportunities and high cost.

3.0 DIESEL HEAT RECOVERY AND SUPPLY APPLICATIONS

3.1 General Applications of the Technology

The recovery and supply of diesel engine heat for building or process heating is based on conventional technology. There have been numerous such projects undertaken in Canada and throughout the world for various unit sizes. Two such installations include Lac La Martre in the Northwest Territories and the Attawapiskat hospital project in Northern Ontario.

The applications basically involve four components:

(a) The transfer of diesel engine cooling jacket water/glycol heat and/or flue gas exhaust heat to a secondary heat carrying medium circuit;

(b) The transport of the secondary circuit heat carrying medium to the heat user;

(c) The transfer of the secondary circuit medium's heat energy to the end user's heating system;

(d) The transport of the cooled secondary circuit medium back to the engine cooler.

The design and success of a given application will depend on

(a) The percentage of diesel engine generator fuel given off as jacket water/glycol heat and/or flue gas heat at various engine generator loads;

(b) The variation of electrical load: hourly, daily, monthly and yearly;

(c) The heat load demand curve on an hourly, daily, monthly basis;

(d) The distance between heat user and heat source;

(e) Competing uses for diesel heat from the source;

(f) The costs of alternative heating fuels.

In operation, the system could be designed to supply a base heat load or the total load, using conventional heating fuels and systems as back-up, controlled by a dual setpoint thermostat.

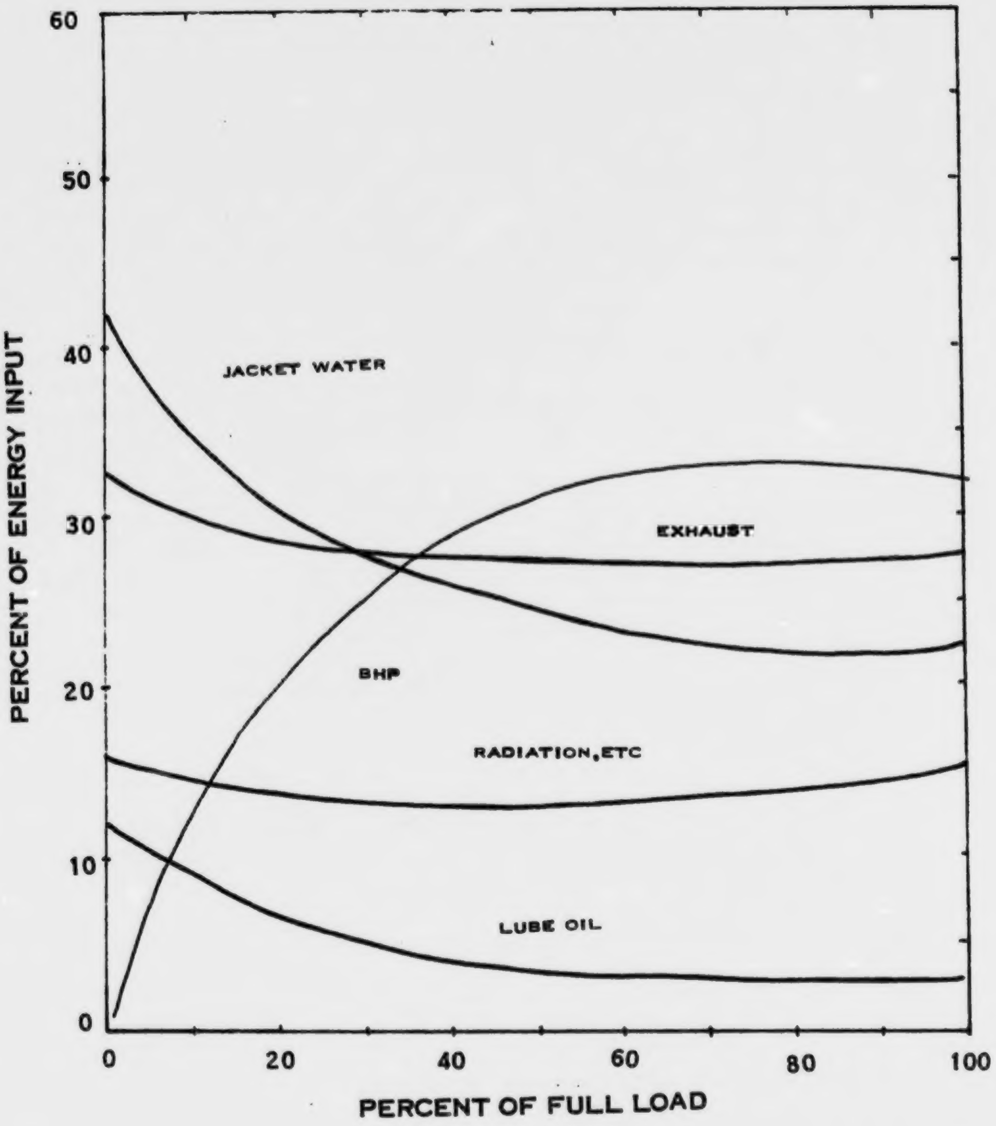


FIGURE 4
HEAT BALANCE FOR A TYPICAL
TURBOCHARGED DIESEL ENGINE

SOURCE ASHRAE SYSTEMS

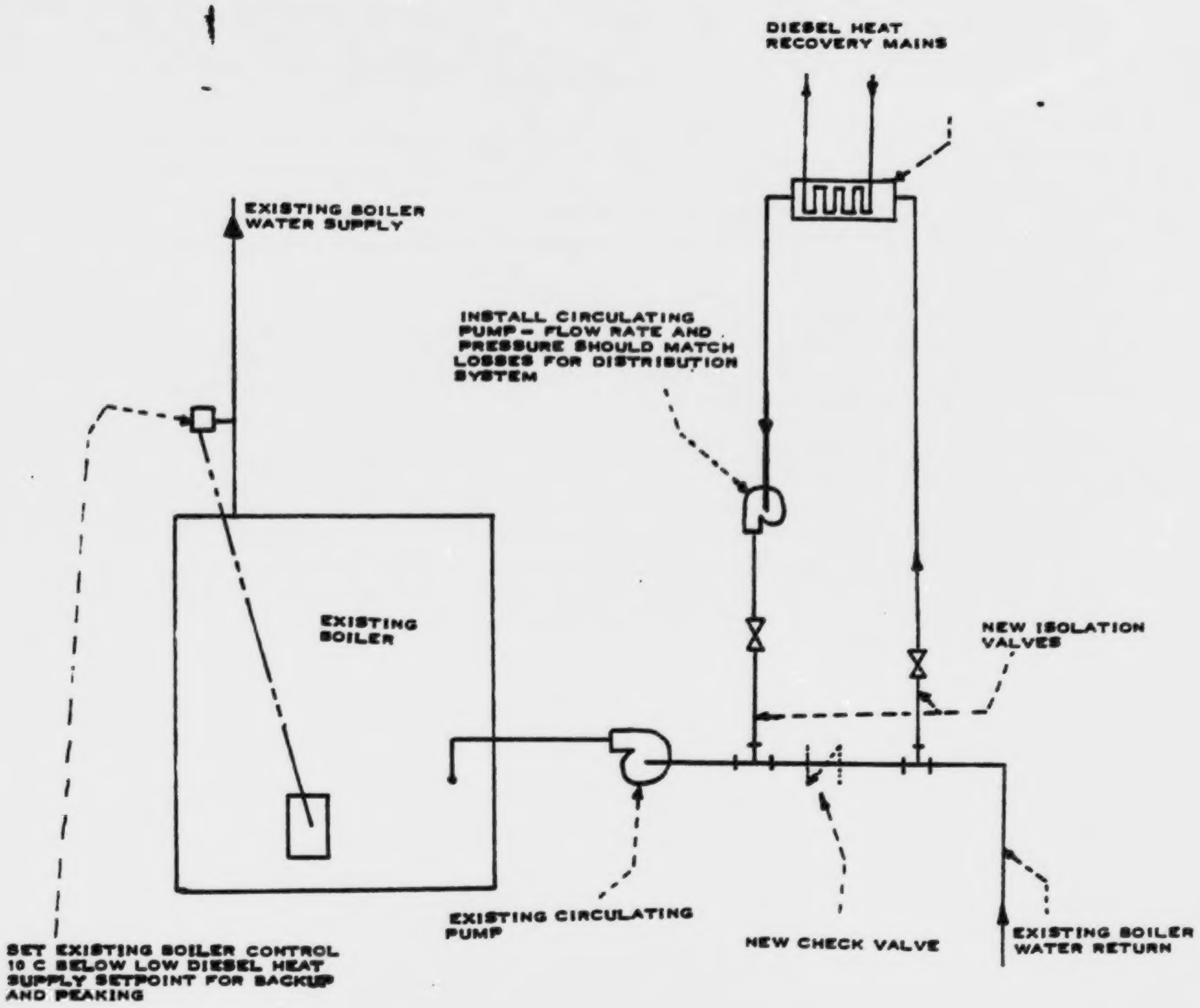
Figures 5 and 6 present illustrations of the types of systems which could be retrofitted to existing heating systems. An existing hot water heating system is generally the preferred situation. The retrofit of an existing forced air system, possible in most circumstances, may involve certain complications of the existing system.

With a hot water system, a diesel heat supply medium to building heating water heat exchanger is readily designed. The diesel heat supply system the existing system as back-up are readily controlled. The back-up system is not adversely affected by the diesel heat system. The two can readily be operated simultaneously as required to meet building/process demands.

With the retrofit of a forced air system, precautions to avoid the failure of the existing system must be taken. The furnace fan motor in a poorly designed system could overheat. Overpressurizing the furnace and ducting is also a possibility.

For full forced air heating (18°C to 66°C), it is desirable to install the heating coil in the building supply duct. This heater will be oversized relative to the existing supply ducts. Otherwise supply air velocity and hot water heating coil pressure differential limitations would be exceeded. Vaned oversized ducting will have to be retrofitted. The vanes will ensure even air flow distribution. An additional duct air pressure drop will result from the heating coil under all furnace operating conditions.

FIGURE 5
TYPICAL HOT WATER HEATING FOR BOILER
DIESEL HEAT RECOVERY


DIESEL HEAT RECOVERY MAINS
EXISTING BOILER WATER SUPPLY
INSTALL CIRCULATING PUMP – FLOW RATE AND PRESSURE SHOULD MATCH LOSSES FOR DISTRIBUTION SYSTEM
EXISTING BOILER
NEW ISOLATION VALVES
EXISTING CIRCULATING PUMP
NEW CHECK VALVE
EXISTING BOILER WATER RETURN
SET EXISTING BOILER CONTROL 10 C BELOW LOW DIESEL HEAT SUPPLY SETPOINT FOR BACKUP AND PEAKING

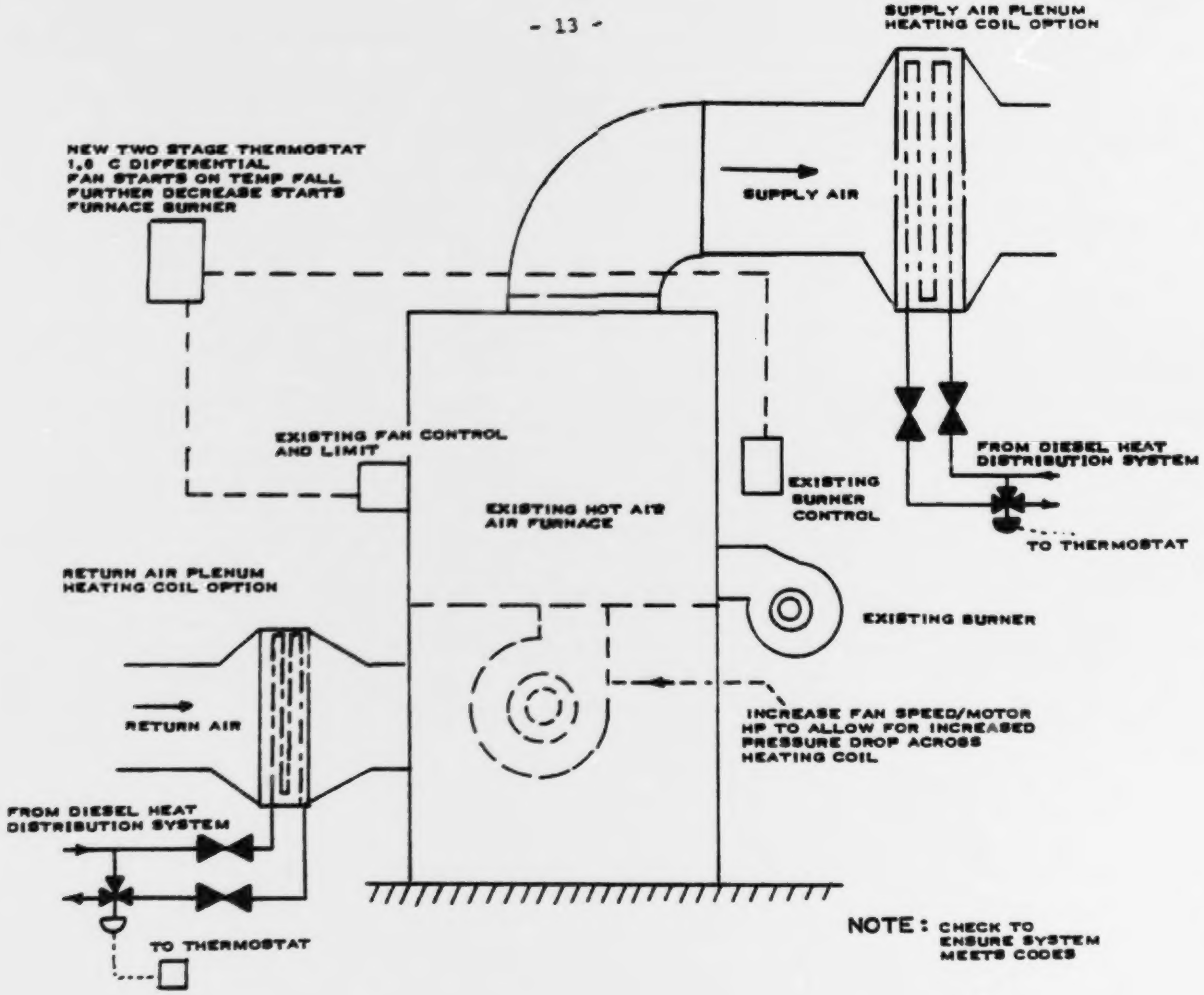


FIGURE 6
ALTERNATIVE CONVERSIONS FOR HOT
AIR SYSTEM

(EXISTING FURNACE HEATING SYSTEM AS BACKUP)

Control of the forced air heating system is also somewhat more complex. The heat transferred to the air by the heating coils is not linear with the heating medium flow. The relationship is as shown in Figure 7 and 8. A system designed for a 11.1°C temperature drop across the coil at design conditions will incur much larger temperature drops at part load flows. In order to protect the diesel engine cooling system, the coolant should be returned at 71°C+. Thus, some of the hot coolant must be bypassed around the heating coil. This further increases the temperature drop of the coolant through the coils. To compensate for this, good equal percentage valve flow control is desirable, along with limited operation at flows in the very low ranges.

The forced air heating system is also not very compatible with simultaneous operation of the two systems. If located in the return ducting, one manufacturer felt that the simultaneous operation of the conventional furnace operation could overheat the furnace fan motor and possibly the furnace heat exchanger. If located in the supply duct, increased pressure drop across the heating coil will occur when the conventional oil heated system operates.

One system which would enable dual operation would be where hot water heating was installed as a baseboard system. The hot water system would be the primary heating system. A dual thermostat would call upon the forced air oil furnace in high heat load circumstances. The disadvantage of this system for retrofit applications is its cost. It may be limited to small, simple installations.

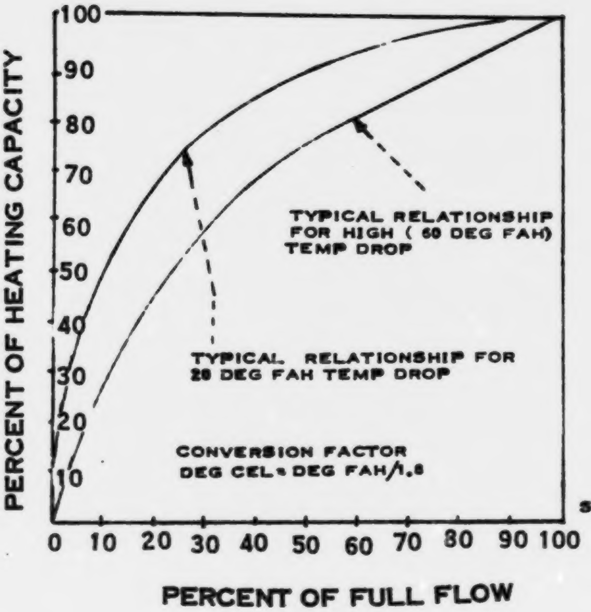


FIGURE 7
HEAT EMISSION VERSUS FLOW
HOT WATER HEATING COIL

SOURCE ASHRAE SYSTEMS

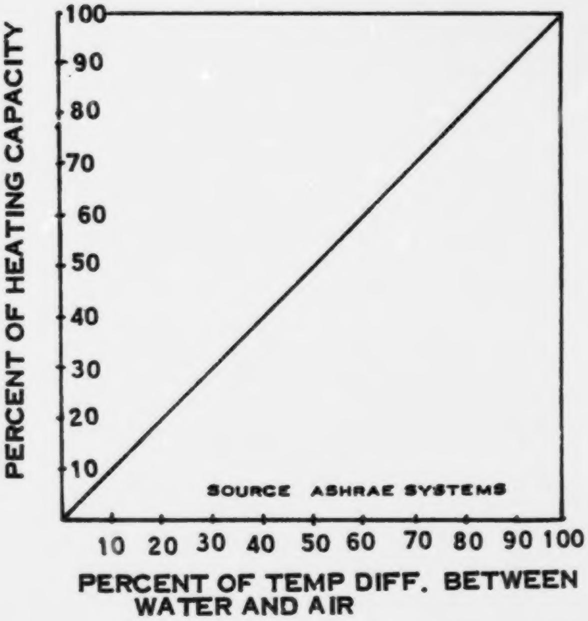


FIGURE 8
CHANGE IN HEAT EMISSION WITH
A CHANGE IN WATER TEMPERATURE

3.2 Assessment of Diesel Heat Supply in Big Trout Lake

Bell Canada Remote Site Staff Facility Heating Requirements

Bell Canada's remote telecommunication sites maintenance staff residence acts as a base of operations for Bell's staff in the north. Crews fly in and out to facilities as maintenance and upgrading are required.

The residence contains 12 bedrooms plus a large apartment for catering staff. It is maintained by outside staff year-round. It also contains a large recreation area, TV room, kitchen/dining room, laundromat, storage facility and mechanical room. It contains about 929 square metres of floor space.

The Bell facility is the closest installation to the Ontario Hydro generating units, about 180 to 240 metres. They are both on the same sideroad off the main road from the airport to the town (Figure 12).

The Bell Canada facility is heated by two ground level 268,000 kJ/h oil furnaces and hot water is supplied by one 2.0 L/h oil heater. The total oil consumption in 1982/83 was 50,850 L at 59¢/L or $30,000. This reflects a somewhat milder winter than normal. It is expected that based on the degree-day and furnace data, the fuel requirement would be approximately 53,250 L or $31,400. Of this, 51,250 would be for space heating.

The Bell Canada facility represents the best application for diesel heat use in Big Trout Lake, and could be used to provide basic data for other future facilities.

The facility is not suitable for a baseboard heating retrofit. The number of installations would be extensive and expensive. There appears to be sufficient space in the furnace room to permit the installation of the large 0.6mx1.07 m heating coils and the ducting and vanes leading up to and away from the furnaces.

Ontario Hydro Diesel Engine Generator Building

Ontario Hydro's generation facility is located about halfway between the community and the airport on Post Island. It is about 180 m from the Bell Canada facility. Figure 9 on page 18 shows their approximate relationship and a proposed route for a waste heat supply system.

Currently, the Ontario Hydro building houses three 125 kW, 156.25 kVA, 1800 rpm machines, equipped with six cylinder, turbo-charged Caterpiller 3306 engines with hydraulic governors and engine coupled radiators. To meet daily peak loads, it has been necessary to have an operator manually parallel the units and remove them for operation at anticipated times during the day or night.

In 1984, DIAND and Ontario Hydro have agreed to replace these old units with three new units and to supply three mainland settlements. The new units are graduated in size, 175 kW, 260 kW and 400 kW. They will likely be equipped with remote external radiators, a micro-computer control system, and a jacket water diesel heat supply system.

The micro-computer control system is designed to automatically select the best available unit for a given community electrical load, to automatically activate and de-activate units, under specific circumstances and to provide load shedding capability under emergency or start-up conditions.

The jacket water heat supply system and remote radiators are another part of the package to reduce costs and improve generation efficiency. The diesel heat from an operating unit will be circulated and some utilized by non-operating units to maintain a temperature compatible with quick automatic start-up. The system will also provide heat to the generator building heating system and possibly to an Ontario Hydro staff trailer/house.

The remaining excess jacket water heat could be utilized for external heating purposes or fed to the external remote radiators. The use of remote radiators also should provide savings, since these units will only operate as required as opposed to the continuous operation with the direct coupled radiators.

Overall, it is expected that savings of at least 10 percent, and most likely 20 percent, of the fuel and maintenance costs can be achieved. The first new units of this design have just been installed at Bearskin Lake. Test results are not yet available.

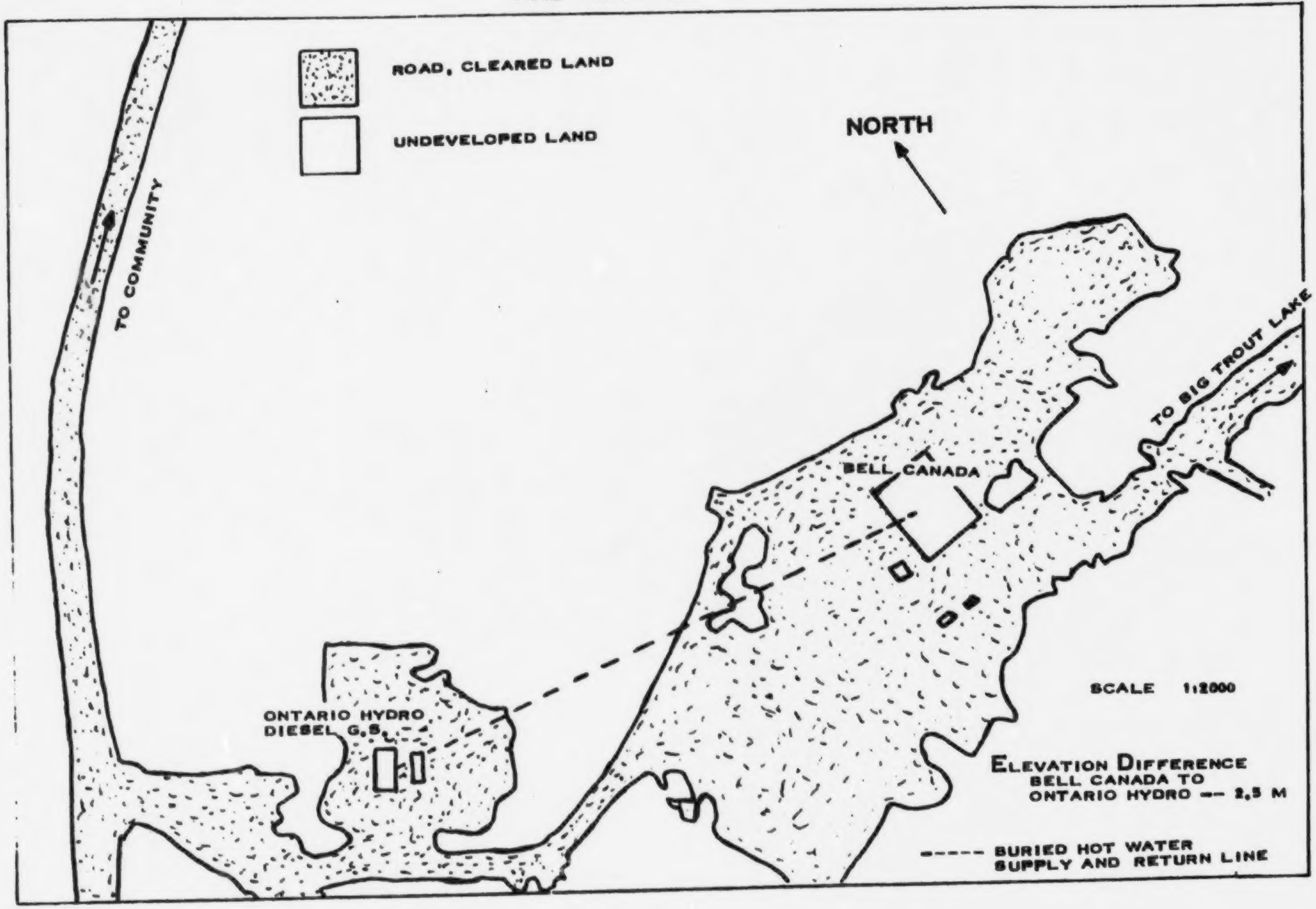
3.2.1 Design of Diesel Heat Recovery and Utilization System

The basis for the design is that sufficient diesel heat medium capacity should be provided to fully replace the heating capacity of the two Bell Canada forced air, oil fuelled, 268,000 KJ/h furnaces. It was assumed that the average peak load would, as a result of the system expansion to the mainland, grow sufficiently to provide the peak heating requirement.

Figures 9 and 10 provide details of the basic heat recovery and supply system. Figure 9 shows the basic pipeline route. Figure 10 shows the simplified design details.

For the purposes of this study, it is assumed that the basic jacket water heat supply system would be in place (at no cost to the excess heat user). The system design for supply of excess heat to the Bell Canada facility would thus only include that equipment from the take-off point A, to the return point B (Figure 10), plus some incremental changes to the basic jacket water heat supply system.

FIGURE 9
BIG TROUT LAKE
PIPELINE LOCATION
HOT WATER DELIVERY
AND RETURN



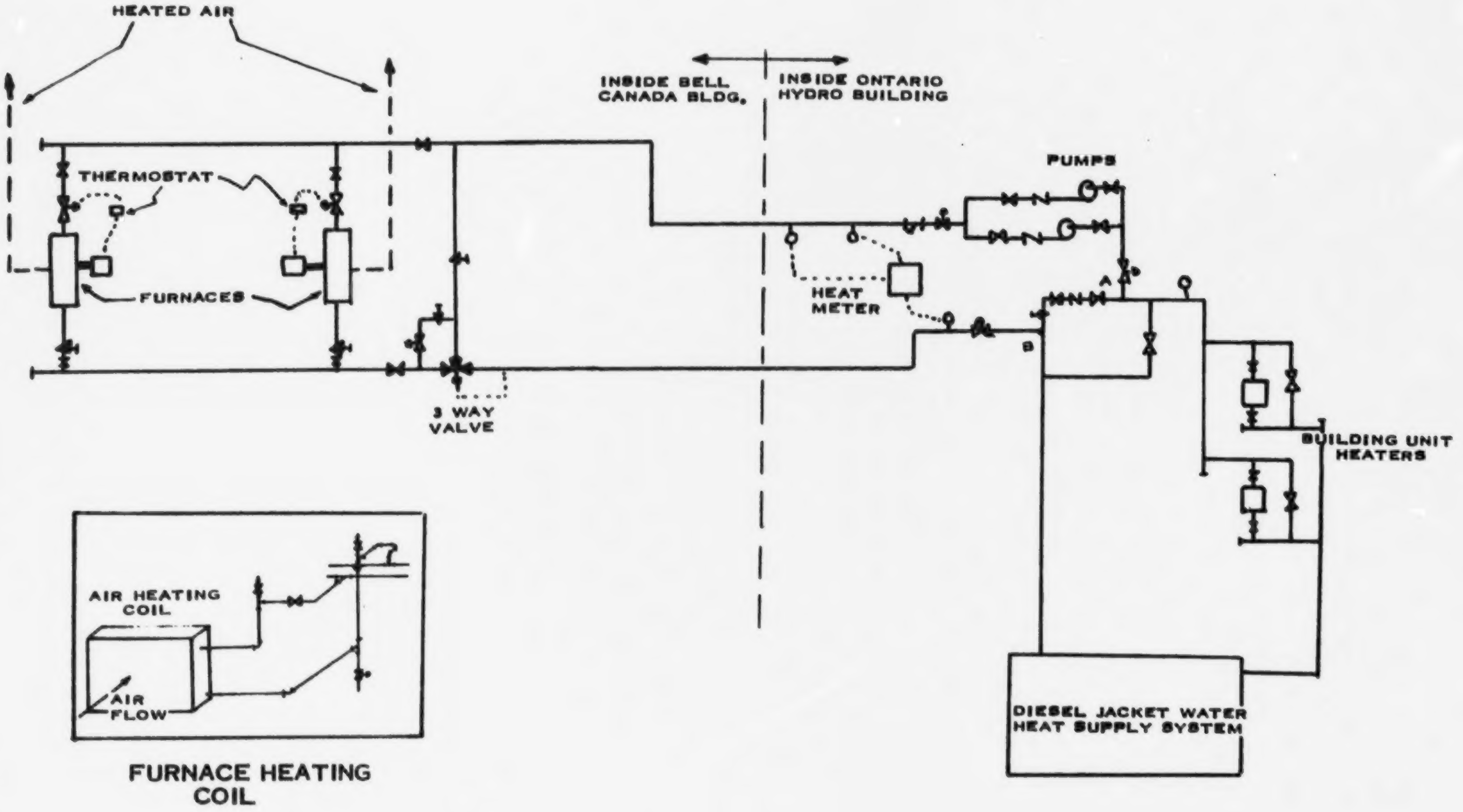


FIGURE 10
DIESEL HEAT TRANSPORT AND DISTRIBUTION SYSTEM

BIG TROUT LAKE – BELL CANADA

The 50/50 ethylene glycol/water (alternatively 50/50 propylene glycol water) heat transport medium from the basic jacket water heat supply system would be taken off at point A. Two centrifugal pumps would be tied to the basic system controls such that necessary diesel engine coolant temperatures would be maintained. Below 76°C, the system controls would prohibit circulation to the external heat supply loop. The two pumps are assumed to supply approximately 3.7 L/s @200 kPa and 1.9L/s @82 kPa. The pumps require 1.12 kW (1.5 HP) and 0.75 kW (1.0 HP) motors respectively.

A heat measuring device is utilized to determine the diesel heat delivered to the Bell facility. Basically the device measures supply and return heating medium temperatures and supply flow. It integrates this information to arrive at a heat supply figure. The device is accurate to ± 5 percent.

The heat metering device could be located at either the Ontario Hydro or Bell facility. Although the Ontario Hydro facility would be preferable from a logistics point of view, a somewhat arbitrary allowance for pipeline losses would be necessary. The Bell facility location would eliminate the need for estimates of pipeline energy losses and would be more versatile in the event other facilities were supplied in the future.

NOTE: DIMENSIONS IN MM
NTS

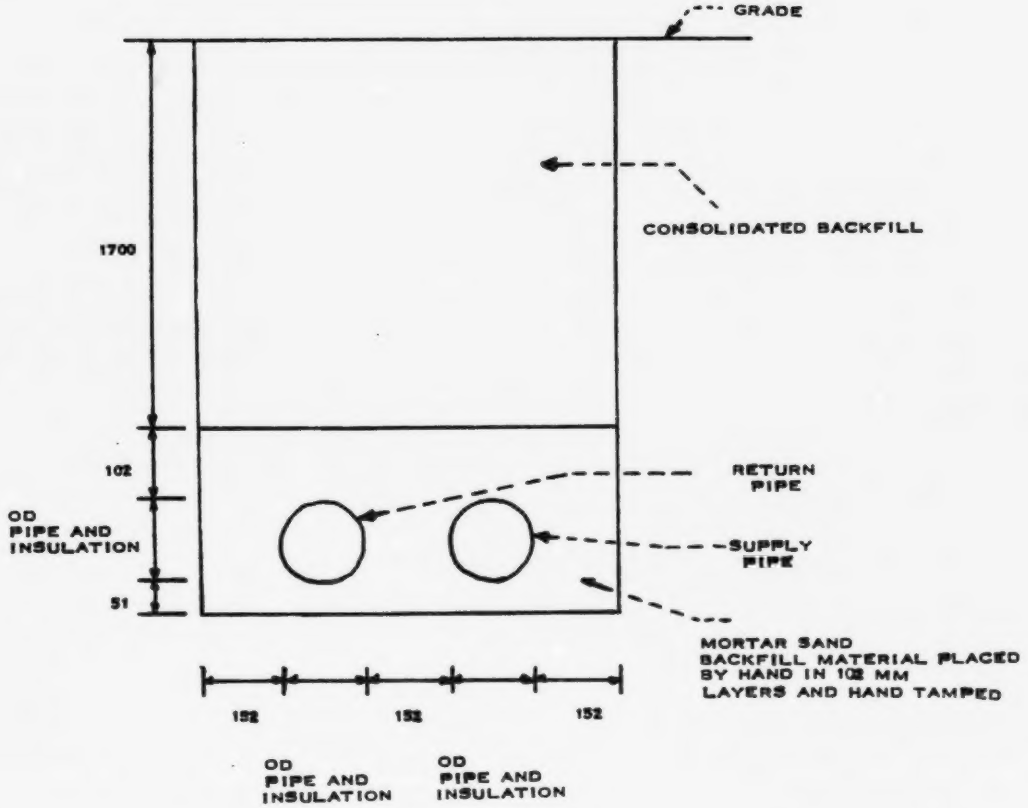


FIGURE 11
TRENCHING DETAIL

The supply and return pipelines between the Ontario Hydro and Bell facilities are 63.5 mm pre-insulated steel pipe, such as RICWIL Steelguard. They have an a coefficient of thermal conductivity or K factor of $10.2 J/(h.m^2.°C/m)$. The line is buried 1.8 m, below grade at the Ontario Hydro facility. The trench fill is as shown in Figure 11. Pipeline sections are 6 metres long and are coupled using quick connect O-ring type joints. The pipeline is 183 metres long from the Ontario Hydro building to the Bell building.

Inside the Bell and Ontario Hydro buildings, welded black steel pipe and fittings are used. Balance and gate valves are utilized to balance line losses to the individual furnaces and to provide manual isolation.

A critical piece of hardware is the 63.5 mm three way diverter valve. This temperature controlled valve regulates the amount of heating medium bypassed around the furnace heating coil to maintain satisfactory return temperatures. It is critical that this unit respond satisfactorily to the heating demands of the unit at low heating medium flow conditions. At a minimum flow, it is desirable that flow would be diverted to one furnace.

At each furnace, the heating medium is fed to a 0.6 m x 1.07 m heating coil. This coil is designed for a 11.1°C heating medium temperature drop at 1.6 L/s for a corresponding 47°C (18-65°C) air temperature rise at $1.3 m^3/S$.

The heating coil imposes an additional 0.085 kPa pressure drop on the furnace fan. As a result, increased fan speed and power are needed. An additional 0.30 Fan HP is drawn per furnace.

3.2.2 Economic Assessment of Heat Supply

A detailed assessment of the economics of jacket water heat supply in this situation depends on a number of pieces of information which are not readily available.

(a) Data on current and anticipated electricity generation patterns, daily, monthly, yearly.

(b) Data on heat use patterns.

(c) Data on current and future Ontario Hydro facilities heating requirements.

(d) Accurate forecasts of fuel price escalation and discount rates.

Without this data, educated estimates are required.

Electrical and Heat Load Estimates

The heat load estimates for the Bell Canada facility on a monthly basis were determined using the monthly distribution of normal degree day data for the region. It was assumed that the average monthly consumption of heating energy would vary as the ratio of this monthly value to the total for the year. No allowance was made for differences daily, or within a month.

The estimated electrical load distribution was more difficult. Records readily available show only monthly peak demand, and at some locations daily peak logs are kept. Continuous records have not been maintained. This could soon change however as the computerized control systems with data logging become operational.

For the purposes of the study an estimate of the distribution of monthly, day and night peaks and average loads was developed. It is based on some very early data taken at Attawapiskat and adjusted to allow for personal observations and comments by others in the field. The assumed electricity demand distribution is not illustrated because of its tentative nature.

Four basic cases are investigated. In the first two, it is assumed that there are no other Ontario Hydro heat loads. If the additional system expansion increases peak demand by 100 kW, the diesel heat supply system could meet approximately 75 percent of the Bell facilities heating requirements. If the current system requirements are used, this becomes 63 percent. In the second two cases, a small Ontario Hydro house/trailer is assumed installed requiring 127,000 KJ/h of capacity and 9200 L of oil equivalent per year. At the anticipated increase in peak load of 100 kW, the diesel heat supply system could meet up to 63 percent of the Bell Canada facility's heating requirements. At current generation levels, this could fall to 43 percent.

Capital Costs

The capital cost of the installed system described briefly in Section 3.2.1 for an in-service date of January 1985 is as follows:

		Jan 1985 $	
	Material	**Labour**	
Heat Transport System	31,300	11,120	
Building Facilities			
• Pumps and Motors	3,990	1,160	
• Heating Coils/Ducting	5,030	3,130	
• Thermostats	670	50	
• Three-way Valves	1,775	105	
• Piping/Valves/Fittings	7,050	3,915	
• Misc	840	860	
• Glycol	3,165	-	
Sub-Total	53,820	20,340	74,160
Sub-Contractor and Contractor Overhead and Profit			22,560
Labour Travel and Expenses			12,660
Contingency/Freight/Engineering			28,320
Sub-Total			137,700
Three Months Interest at 14%			4,800
Total Capital Cost			$142,500

It should be recognized that there has been no capital cost component included for the basic jacket water heat supply system. If such a system had to be designed and installed and charged to an external heat user, the additional capital cost could approach $50,000 to $80,000.

O&M Costs

Operating and maintenances costs in 1985 $ for the system were evaluated on the basis of increased furnace fan and pump motor energy requirements, a percentage of equipment capital cost and an allowance for maintenance personnel travelling/living expenses:

		1985 $
Additional Furnace Fan Motor Energy	@ 41¢/kWh.....	$ 1000 /a
Additional Circulating Pump Motor Energy	@ 41¢/kWh	$ 2250 /a
Equipment O&M (1% of Material Cost) + Mtce Personnel Travelling/Living Expenses		$ 2990 /a
	Total O&M Costs	$ 6240 /a

Bell Facility Heat Oil Savings

As mentioned previously four cases are examined covering a Bell Canada fuel saving of 43 percent to 75 percent. These represent an realistically optimistic assessment of the savings possible.

	OH Trailer/House		No OH Trailer/House	
	Current Electricity Consumption	Anticipated New Elec Consumption	Current Electricity Consumption	Anticipated New Elec Consumption
% of Heating Fuel Oil	43%	63%	63%	75%
Fuel Saved(L)	21137	30969	30969	36600
1985 $/A (@ 69.3¢/L)	$14650	$21500	$21500	$25400

Life Cycle Present Worth Project Costs

Based on the 1985 capital, operating and maintenance and fuel saving cost data and the escalation and interest data in Appendix B, the following 15 year life cycle present worth project costs were developed. No retirement values were assumed for system components as a result of the uncertainty regarding system life. A negative Life Cycle Present Worth Project Cost indicates a life cycle present worth project saving, indicating that the project is feasible provided a 15 year payback at the assumed interest rates is acceptable to the parties involved.

TABLE 2

15 Year Life Cycle Present Worth Project Cost

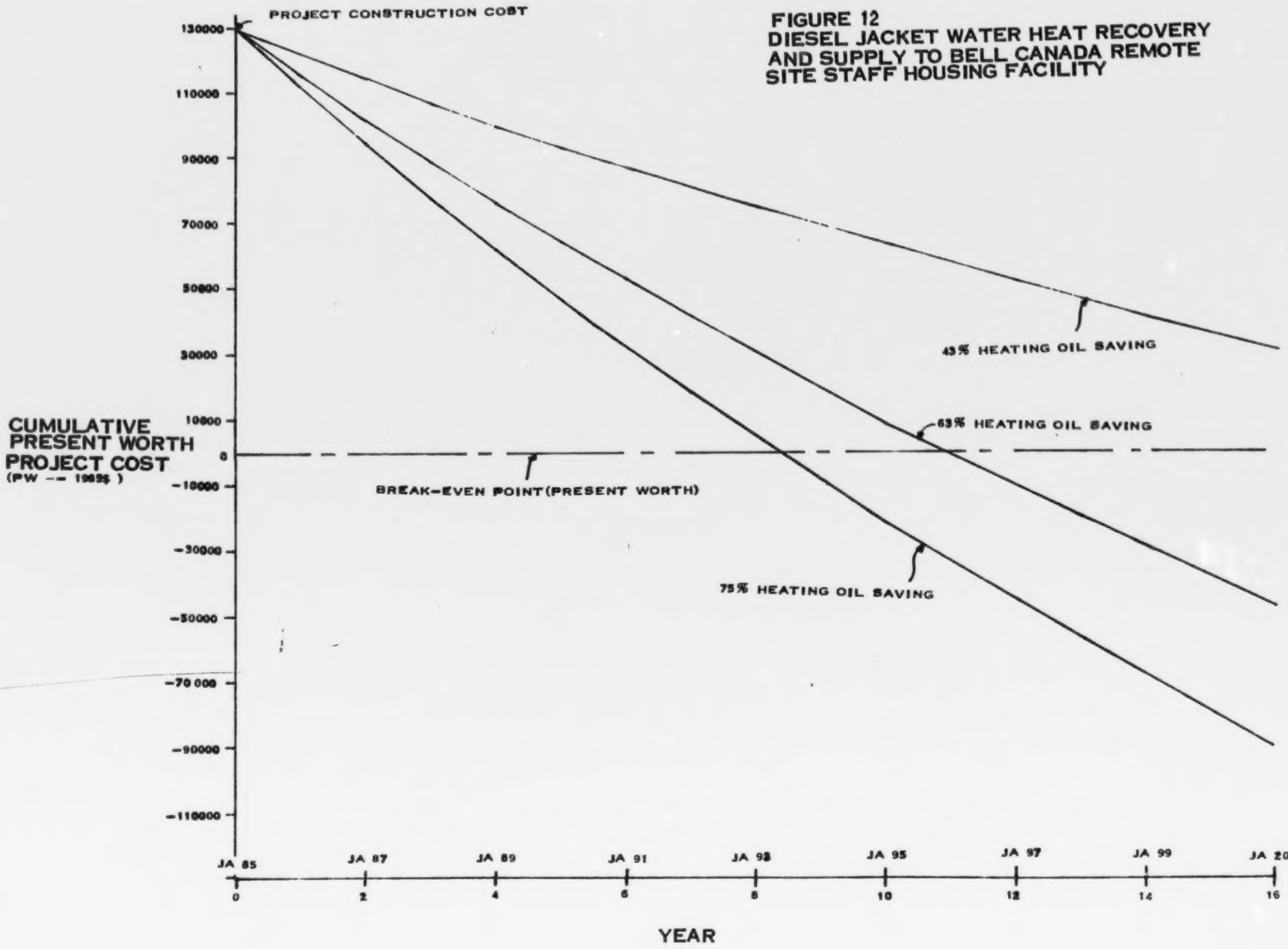
Big Trout Lake Diesel Heat Supply

Cost Component	75% Fuel Oil Saving	63% Fuel Oil Saving	43% Fuel Oil Saving
1985$ Capital	142,500	142,500	142,500
LCPW 1985$ O&M	65,285	65,285	65,285
LCPW 1985$ Fuel Cost	- 285,500	- 241,700	- 164,700
15 Year LCPW Project Cost (1985$)	- 77,715	- 33,915	+ 43,085

Figure 12 presents a year by year present worth project cost summary. A slightly lower initial capital cost is shown. It represents a compromise between the base case value and a more optimistic case. It illustrates the time necessary to reach the project break-even point for the three fuel oil savings levels. The 75 percent fuel oil saving scenario reaches the present worth break-even point by the ninth year while the 63 percent case reaches it by the eleventh year. The 43 percent case does not reach it by year 16 and would not likely before the twenty-second year.

Figure 13 presents a similar year by year project present worth cost summary, but includes a high fuel oil escalation and a low discount rate alternative scenario (Appendix B) for each of the 43 percent and 75 percent heating oil saving cases. It becomes clear that the present worth pay-back period will improve by up to two years in the 75 percent case and up to six years in the 43 percent case.

FIGURE 12
DIESEL JACKET WATER HEAT RECOVERY AND SUPPLY TO BELL CANADA REMOTE SITE STAFF HOUSING FACILITY



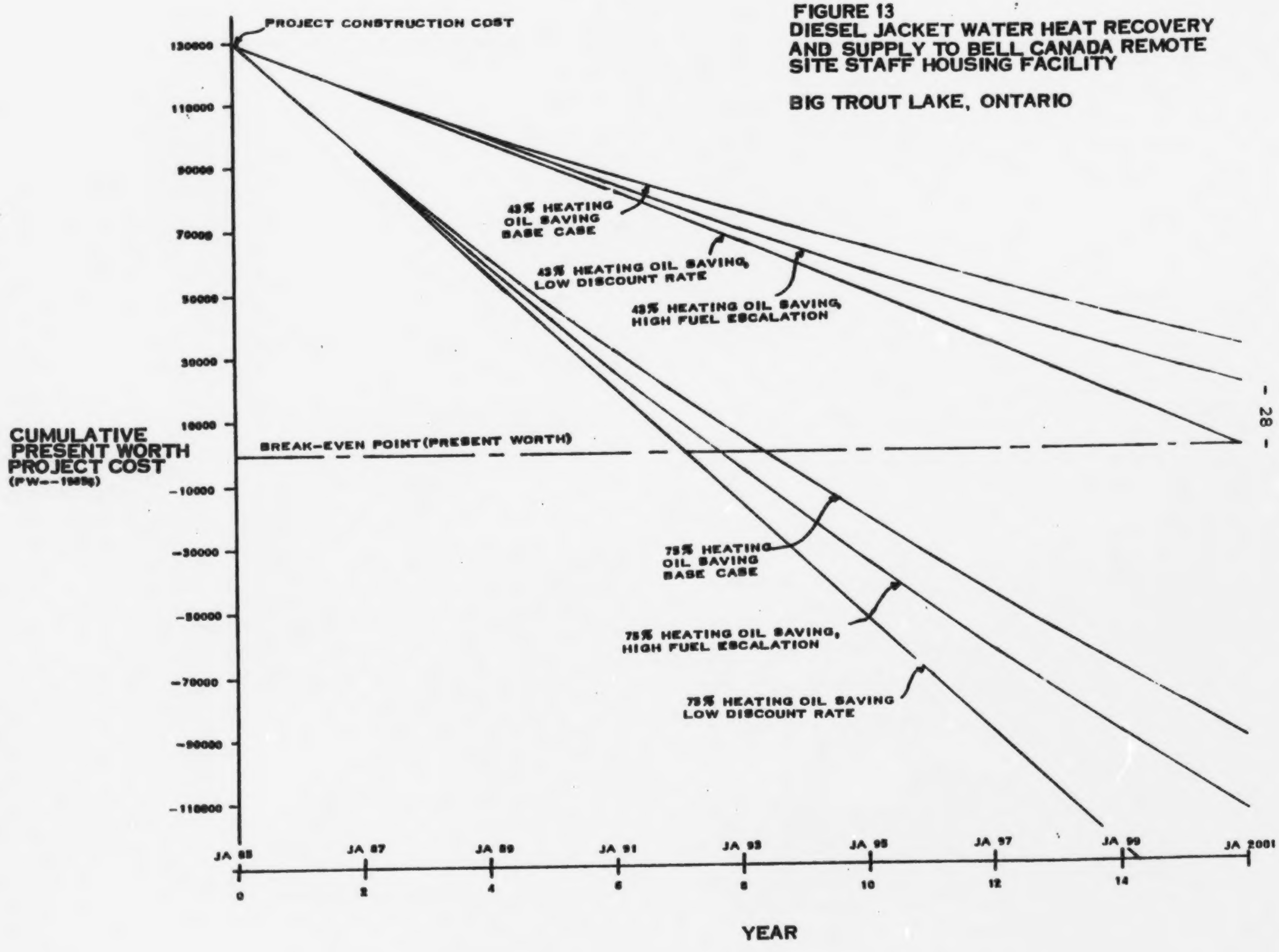


FIGURE 13
DIESEL JACKET WATER HEAT RECOVERY AND SUPPLY TO BELL CANADA REMOTE SITE STAFF HOUSING FACILITY

BIG TROUT LAKE, ONTARIO

3.2.3 Project Implementation

Prior to project implementation, several issues will have to be addressed and resolved, including:

(a) The development of a firm pricing policy for Ontario Hydro diesel heat energy sales.

(b) The development of a policy on the division of capital costs (Ontario Hydro practice to date is to pay for equipment to plant boundary).

(c) The uncertainty over expected new community electricity demand levels and pattern.

(d) The uncertainty over the variation of electricity and heat demand with time of day, week, month and year.

(e) The uncertainty over future Ontario Hydro heat energy requirements.

(f) The minimum eight years, maximum 22 years return on investment.

(g) The uncertainty regarding compatibility of external heat supply system with Ontario Hydro diesel jacket water heat supply system.

(h) Potential native peoples objections to diesel heat use project.

The major factor which influences this and other diesel heat projects would be the formula developed for diesel heat pricing. In this instance, if anything but the cost to supply the heat were charged, i.e., if a price were charged for the energy value, the pay-back period for the user would increase significantly. The project would become much less sound.

The pay-back period and the uncertainty over likely heating oil savings are also major factors. An eight year present worth pay-back at approximately 13 percent discount rate is marginal for a private company. Given the uncertainty that the results of this study might be optimistic and that an "energy value" for the diesel heat might be charged, it is unlikely that a private company would undertake this project without significant subsidies and/or financial guarantees.

3.3 Assessment of Diesel Heat Supply to MTC's Airport Facilities in Sandy Lake

MTC Airport Facilities

The MTC airport bunkhouse and garages are the closest facilities to the existing diesel generating station. One garage is a maintenance garage and the other an unheated warehouse. Figure 14 on page 32 illustrates the layout of these facilities relative to the Ontario Hydro diesel generator building.

The maintenance garage has two small 172,000 kJ/h forced air furnaces. Only one is used according to local MTC representatives. The other is a back-up. The bunkhouse has a single 123,000 kJ/h unit. The temperatures in the bunkhouse and maintenance garage are set at a lower temperature when not in use.

Fuel consumption data for the MTC facilities are not readily available. For the purposes of this study, consumption figures had to be determined, based on degree-day data and furnace size data. Since there is not full time occupation, an estimate of the appropriate degree-days information was necessary. A value of 5600°C degree-days was determined for the garage and 6638°C for the bunkhouse. Based on this method, it is estimated that 22,000 L/a of fuel oil is required at a cost of $13,400/a (1983). This is in relatively good agreement with an earlier Hedlin estimate of 20,462 L which was based on supply records.

The MTC bunkhouse facility may not be suitable for a furnace plenum heating coil retrofit. Furnace room space limitations make this approach appear infeasible. For the purposes of this study, a diesel heat medium baseboard heater system has been adopted. Individual baseboard heater units would be placed in the bedrooms, the office, the kitchen, the furnace and utility rooms and the hallway. The units could be supplied with either individual room thermostats or a single bunkhouse thermostat set independently of that for the forced air oil fuelled furnace which would now act as a back-up heating system.

The MTC heated garage facility is suitable for either a furnace supply plenum heating coil retrofit or a multiple unit heater building retrofit. The unit heater approach may prove the easiest and most effective means of operation. It does not interfere with conventional furnace operation. It provides different levels of heating capability and is relatively easy to retrofit.

Ontario Hydro Diesel Engine Generator Building

Electricity in Sandy Lake is supplied from a central generating station operated by Ontario Hydro. The facility contains three generating units, two 175 kW machines and one 440 kW machine. It is located approximately twenty-one metres from the MTC facilities at the airport (Figure 14 on page 36).

Unit 1 is a 175 kW, 218.7 kVA 1800 rpm machine connected to a six cylinder, turbo-charged Allis Chalmers engine, equipped with a hydraulic governor. This unit is the oldest and is incapable of meeting community peak loads, unless paralleled with other units.

Unit 2 is a 175 kW, 218.7 kVA 1800 RPM machine equipped with a six cylinder, turbo-charged in-line Caterpillar 3406 engine and Newage Stamford Generator. This unit is equipped with a Barber-Coleman DYN1 Electronic Governor. This unit is used in parallel with Units 1 or 3 to meet system peaks. The equipment was supplied by Mechron Engineering and Powell Equipment.

Unit 3 is a 440 kW, 412 kVA, 1800 RPM machine equipped with a V12, dual turbo-charged Caterpillar 3412 engine and a Newage Stamford 456.25 kVA rated generator. The unit is equipped with a Woodward Electronic Governor, for parallel operation. It is capable of meeting the community peaks in the coming year.

3.3.1 Design of Diesel Heat Recovery and Utilization System

As for the Big Trout Lake application, the basis for the design of this application is that sufficient diesel heat medium capacity should be provided to fully replace the heating capacity of all of the MTC furnaces in Sandy Lake.

Figures 14 and 15 provide details of the basic heat recovery and supply system. Figure 14 shows the basic pipeline route. Figure 15 shows the simplified design details.

For the purposes of this study, it is assumed that the basic jacket water heat supply system would be in place, at no cost to the excess heat user. The system design for supply of excess heat to the MTC facilities would thus only include that equipment from the take off point A, to the return point B, plus some incremental changes to the basic jacket water heat supply system.

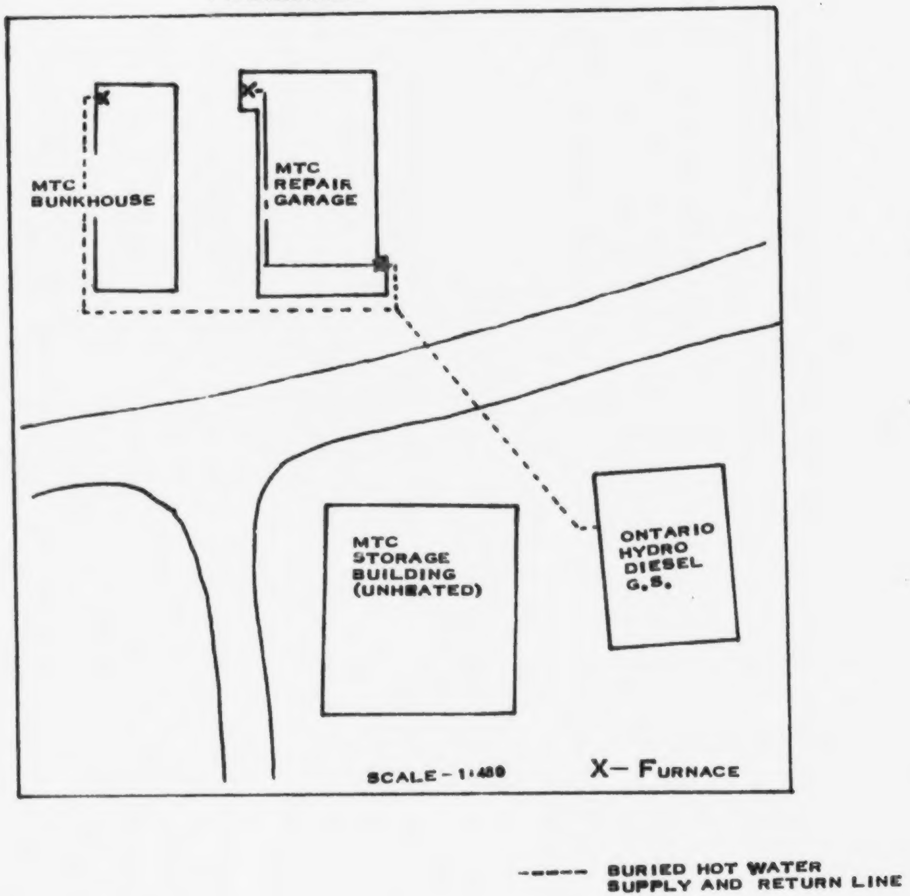
The 50/50 ethylene glycol/water (aternatively 50/50 propylene glycol/water) heat transport medium from the basic jacket water heat supply system would be taken off at point A. Two centrifugal pumps would be tied to the basic system controls such that the necessary diesel engine coolant temperatures would be maintained. Below 76°C at point A, the system controls would prohibit circulation of engine secondary circuit coolant to the external heat supply loop. The two pumps are each designed to supply 2.73 L/s at 120 kPa. The pumps require 0.75 kW (1 HP) motors.

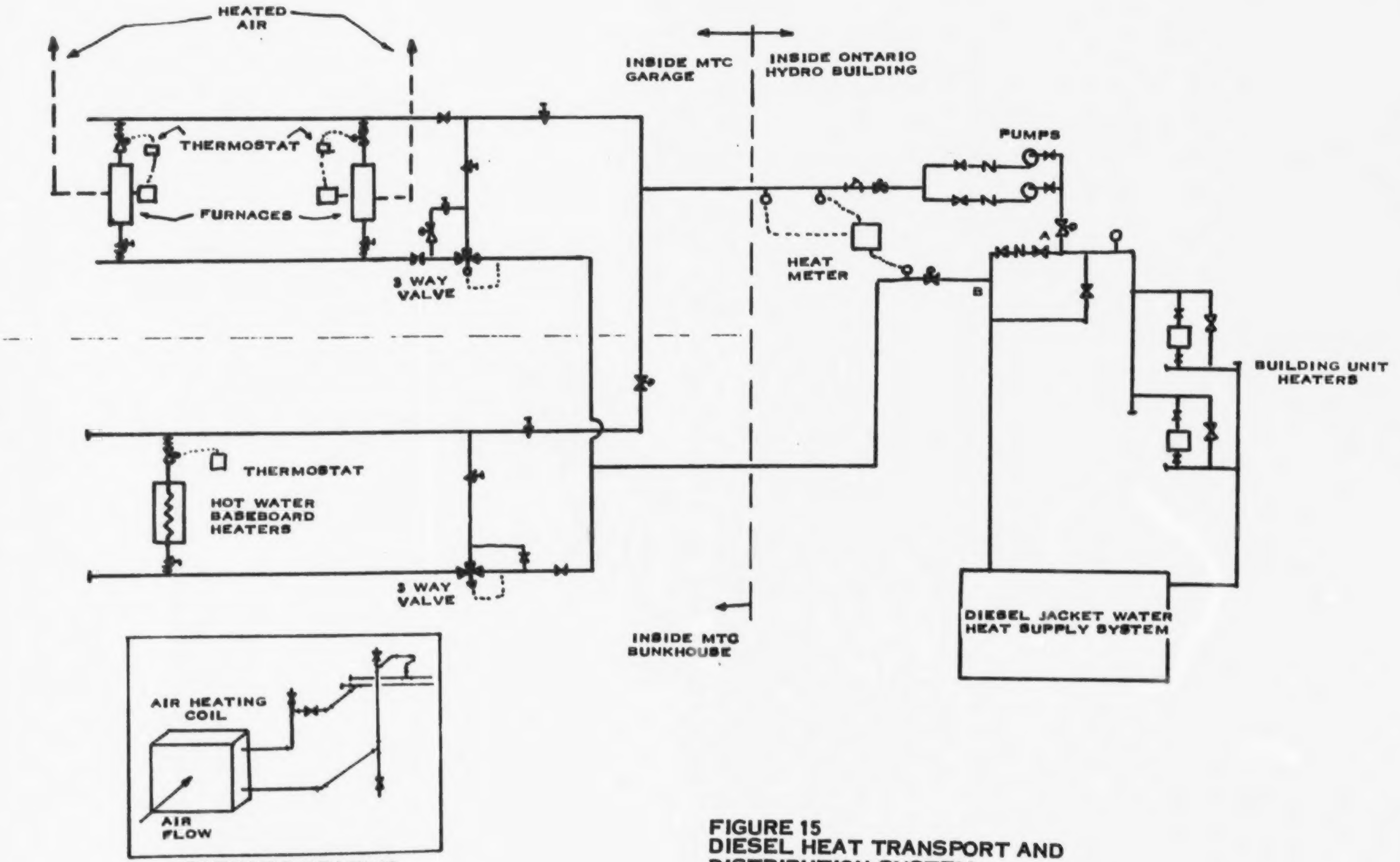
A heat measuring device similar to that use in the discussion on Big Trout Lake is utilized.

The supply and return pipelines between the Ontario Hydro and MTC facilities are pre-insulated steel pipe, such as RICWIL Steelguard. The pipelines are buried side by side 1.8 m deep. The trench is filled as in Figure 11, page 23. As with Big Trout Lake, individual sections (up to 6 metres) are coupled using quick connect O-ring type joints.

Inside the Ontario Hydro and MTC buildings, welded black steel pipe and fittings, insulated as required, are used. Balance and gate valves are utilized to balance line losses to individual heaters and to provide manual isolation.

FIGURE 14
SANDY LAKE
HEAT SUPPLY TO
MINISTRY OF TRANSPORTATION
AND COMMUNICATIONS (MTC)
FACILITIES


MTC BUNKHOUSE
X
MTC REPAIR GARAGE
X-
MTC STORAGE BUILDING (UNHEATED)
ONTARIO HYDRO DIESEL G.S.
SCALE - 1:480
X- FURNACE
----- BURIED HOT WATER SUPPLY AND RETURN LINE



FURNACE HEATING COIL

FIGURE 15
DIESEL HEAT TRANSPORT AND DISTRIBUTION SYSTEM

SANDY LAKE MTC AIRPORT APPLICATION

Three-way diverter valves are critical components at each building's inlet. The temperature controlled valves regulate the amount of heating medium bypassed around the heaters to maintain satisfactory return temperatures. These units must respond satisfactorily to the heating demands at low heating medium flows. At minimum flows, it is desirable that flow be concentrated to specific units.

In the bunkhouse, the heating medium is fed to sixteen extended fin tube convection baseboard heaters. Each is designed to draw sufficient heating medium fluid to produce approximately 900 KJ/h of heat, with a 11.1°C heating medium temperature drop.

In the garage, either individual unit heaters or supply duct heating coils could be utilized. In either case, the design heating medium temperature drop would be 11.1°C and the total heat produced 330,000 KJ/h maximum.

3.3.2 Economic Assessment of Heat Supply

As was the case for Big Trout Lake, significant pieces of data needed for an accurate assessment of the economics of jacket water heat supply in this situation are unavailable, including

(a) Data on current and anticipated electricity generation patterns, daily, monthly and yearly.

(b) Data on total heat use, and heat use pattern.

(c) Data on potential community facilities energy requirements and fuels.

(d) Accurate fuel price and discount rate forecasts.

Without this data, educated estimates have been made which form the basis for the assessment.

Electrical and Heat Load Estimate

The heat load estimates for the MTC facilities on a monthly basis were determined using the monthly distribution of normal degree day data for the region and the estimated annual fuel requirement. It should be noted that considerable uncertainty is associated with the annual figure as well. No attempt was made to differentiate between daily and hourly variations in heating requirements.

The electrical load distribution was estimated in the same manner as for Big Trout Lake. There is no recent data available on load with time. This is expected to change as data becomes available from new units being installed with micro-computer data logging.

For the purposes of the study, an estimate of the distribution of monthly, day and night peaks and average loads have been developed. This was developed from early data on Attawapiskat, adjusted to take into account personal observations and comments by others in this area. It must however be recognized that each community should be expected to have its own specific pattern which will vary over time. It was not deemed desirable to illustrate electricity and heat demand distributions, particularly the electricity demand distribution, because of their somewhat tentative nature.

Two basic cases were assumed in developing the economics of diesel heat supply to the MTC facilities. In the first, it is assumed that 100 percent of the required heat could be supplied, and in the second, that 75 percent of the required heat could be supplied. Further, a 100 percent heating oil replacement case for a high oil escalation scenario and for a lower discount rate scenario were assessed.

Capital Costs

The capital costs of the installed system described briefly in Section 3.3.1 for an in-service date of January 1, 1985 is as follows.

			January 1985 $
	Material	Labour	
Heat Transport System	10,110	6,880	
Building Facilities			
• Pumps and Motors	3,950	1,065	
• Heating Coils/Ducts/ Unit Heaters	6,440	5,205	
• Thermostats	1,000	80	
• Three-way Valves	2,900	210	
• Piping/Fittings/Valves	6,190	3,630	
• Misc	730	750	
• Glycol	525	-	
Sub-Total	31,845	17,820	49,665
Sub-Contractor/Contractor Overhead and Profit			16,225
Labour Travel and Expenses			13,820
Contingency/Freight/Engineering			22,750
Sub-Total			102,460
Three Months Interest at 14%			3,600
Total Capital Cost			106,060

It should be recognized that there has been no capital cost component included for the basic jacket water heat supply system. If such a system had to be designed, installed and charged to an external heat user, the additional capital cost could approach $50,000 to $80,000 plus.

O&M Costs

Operating and maintenance costs in 1985$ for the system were evaluated on the basis of increased furnace fan and pump motor energy requirements, a percentage of equipment capital cost and an allowance for maintenance personnel travelling/living expenses.

	1985 $
Additional Furnace Fan Motor Energy ...... @ 41¢/kWh	$ 523/a
Additional Circulating Pump Motor Energy . @ 41¢/kWh	$1047/a
Equipment O&M ....1% of Material Capital Cost + Mtce Personnel Travelling/Living Expenses	$2570/a
Total O&M Cost	$4140/a

Maintenance Facility Heating Oil Savings

Two cases are examined, an MTC heating oil savings of 100 percent and of 75 percent. No consideration was given to the requirements of an Ontario Hydro house/trailer. The existing Sandy Lake Ontario Hydro house is too remote from the station. The MTC fuel consumption data used is that determined by R. Hedlin and Associates. This value is based on actual fuel deliveries and corresponds well to a calculated value based on degree day estimates of 22000 L (Appendix A).

	100% Heating Oil Saving	75% Heating Oil Saving
L/a Saved	20,462	15,347
1985 $/a @ 69.3 ¢/L	$14,179	$10,634

Life Cycle Present Worth Project Costs

Based on the 1985 capital, operating and maintenance and fuel savings cost data, and the fifteen year escalation and interest data in Appendix B, the following fifteen year life cycle present worth project costs were developed. No retirement values were assumed for system components as a result of the uncertainty regarding system life. A negative life cycle present worth project cost indicates a life cycle present worth project savings, indicating that the project is feasible provided a fifteen year pay-back at the assumed interest rates is acceptable to the parties involved.

TABLE 3

15 Year Life Cycle Present Worth Project Cost

Sandy Lake Diesel Heat Supply to MTC Airport Facilities

	100% Fuel Oil Saving	75% Fuel Oil Saving
Cost Component		
- 1985 Capital Cost	106,060	106,060
- LCPW 1985 O&M Cost	42,362	42,362
- LCPW 1985 Fuel Cost	- 159,372	- 119,529
15 Year LCPW Project Cost	- 10,950	+ 28,893

Figure 16 presents a year by year present worth project cost summary, including base case 100 percent and 75 percent fuel oil savings, and a higher fuel escalation and a lower discount rate case for the 100 percent fuel oil savings case. The figure is based on an initial capital cost of $100,000. The base cases break-even in 13 to 24 years respectively; the higher fuel escalation case after 11 years and the lower discount rate case after ten years.

It should be noted that there may be room for reductions in the capital of up to $20,000. This would result in a much improved economic assessment. The break even point could be reduced by three and seven years for the base of 100 percent and 75 percent heating oil saving cases respectively.

3.3.3 Project Implementation

Prior to project implementation, several issues will have to be addressed and resolved, including:

(a) The development of a firm pricing policy on Ontario Hydro waste heat energy sales.

(b) The development of a policy on the division of capital cost (Ontario Hydro practice to date is to pay for cost up to plant boundary).

(c) The uncertainty over current and future MTC airport heating requirements and resulting fuel savings potential.

(d) The long pay-back period - 13 to 24 years, minimum 10 years.

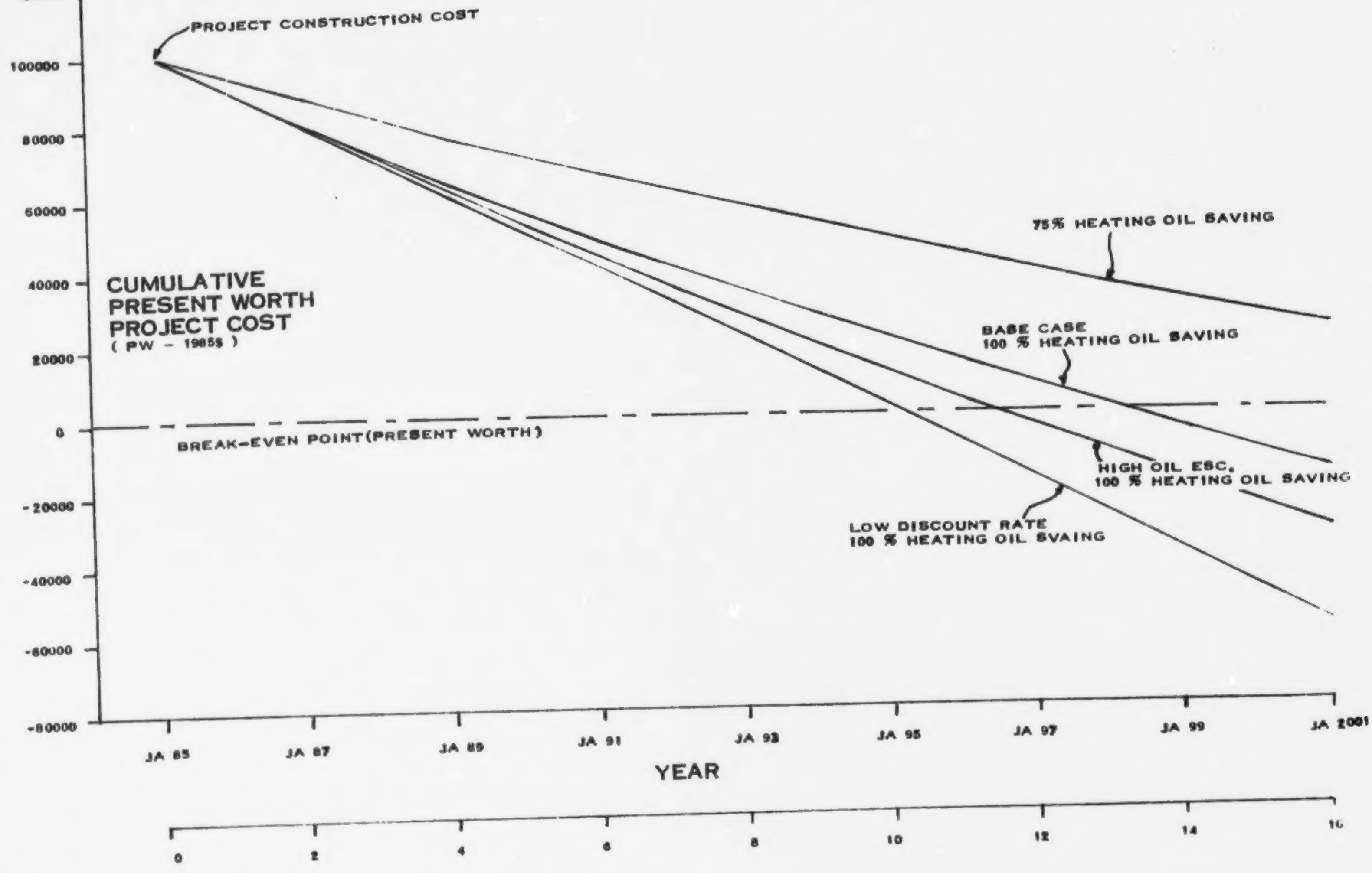
(e) Future potential waste heat sales opportunities.

Several of the other items which were discussed in relation to Big Trout Lake exist, but to a much lesser extent. The quantity of diesel heat available is much larger and the heat demand much smaller.

The major uncertainty relates to how much heating fuel oil can be saved. At the estimated MTC heating oil consumption levels, even 100 percent fuel oil saving gives only a 13 year pay-back, possibly as low as 10 years with lower discount rates or a reduced capital cost. This would likely be unacceptable to a private corporation but may find backers in the Ministry of Transportation and Communication if details can be worked out, and especially if capital costs can be reduced.

FIGURE 16
DIESEL JACKET WATER HEAT RECOVERY AND SUPPLY TO MTC BUNKHOUSE AND GARAGE FACILITIES

SANDY LAKE, ONTARIO



3.4 Assessment of Diesel Heat Supply to Sandy Lake School

Sandy Lake School

The Sandy Lake School consists of several main buildings and numerous teacherages, as well as other ancillary buildings. Space and hot water heating in the main building is provided by oil fuelled equipment. Figure 17 is a sketch of the school facilities, locating the major heating facilities.

The 1982/83 fuel consumption at Sandy Lake School according to a DIAND source was 272,400 litres. This is a relatively good agreement with R. Hedlin values of 272,760 litres. Based on furnace and degree-day data, the normal fuel consumption would be expected to be about 255,000 litres for school building space heating and 150,000 litres for the teacherages. A rough estimate of individual building consumption based on their unit rating and normal degree-days is as follows:

• Main School Building	- Mechanical Room 1	55,000 L
	- Mechanical Room 2	
	- Furnaces	55,000 L
	- Hot Water	12,000 L
	- Mechanical Room 3	66,000 L
• Two Room School Building		22,000 L
• Three Room School Building		22,000 L
• Workshop/Home Ec Building		22,000 L
• Teacherages (15)		150,000 L

The value of the fuel at $0.693/L (1985) is $281,000 (405,000 L) or $189,000 (272,400 L).

For the purposes of this study, it was assumed that diesel heat would be supplied to (a) Furnace Room No. 3 which contains 2 x 396,000/116,000 KJ/H forced air, oil fuelled furnaces or (b) Furnace Room No. 3, and Furnace Room No. 2 which contains 2 x 293,000 KJ/H furnaces (and 2 x 268,000 KJ/H hot water heaters). Each furnace is assumed capable of being fitted with a diesel heat medium heating coil and the required expanded duct work area.

Ontario Hydro Diesel Generator Building

Details of the Sandy Lake diesel generator building are available in Section 3.3 and also Appendix A. The one-way distance to Sandy Lake School is approximately 1204 m (Figure 18 on page 51).

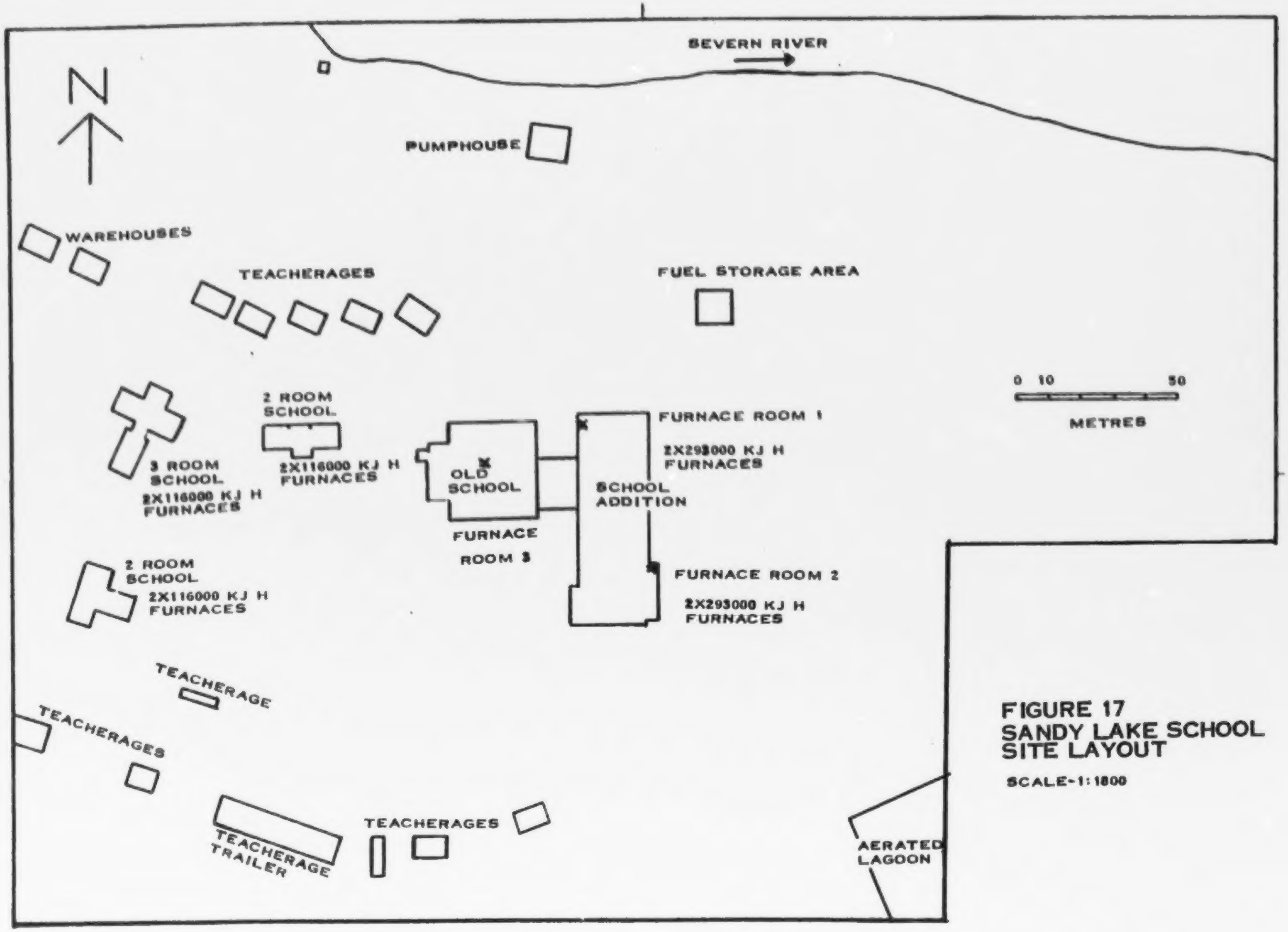


FIGURE 17
SANDY LAKE SCHOOL
SITE LAYOUT

SCALE-1:1800

3.4.1 Design of Diesel Heat Recovery and Utilization System

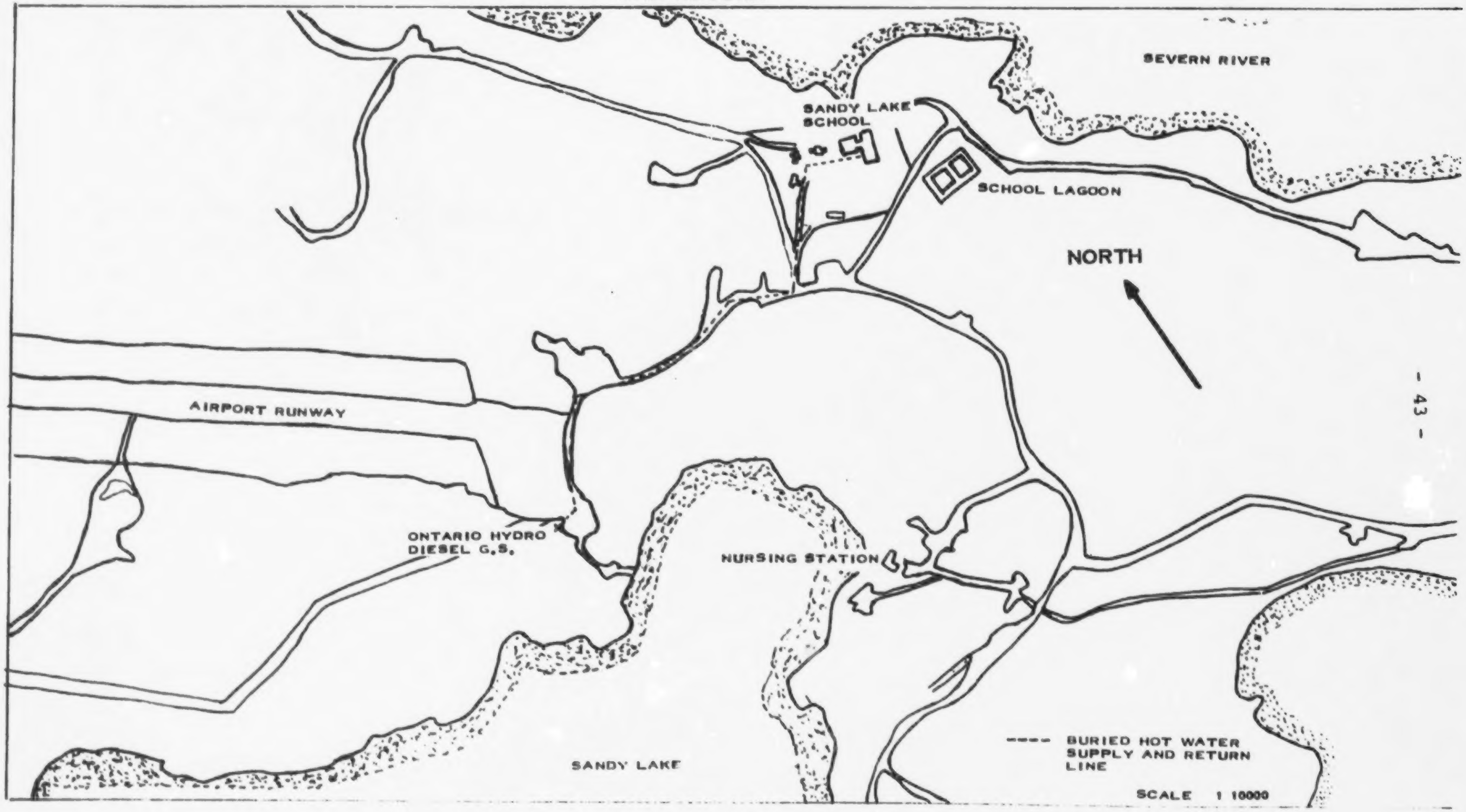
The basis for the design of this system is that sufficient diesel heat medium capacity, up to the maximum available, should be provided. The purpose is to replace as much of the heating capacity of the Sandy Lake School Heating System as possible.

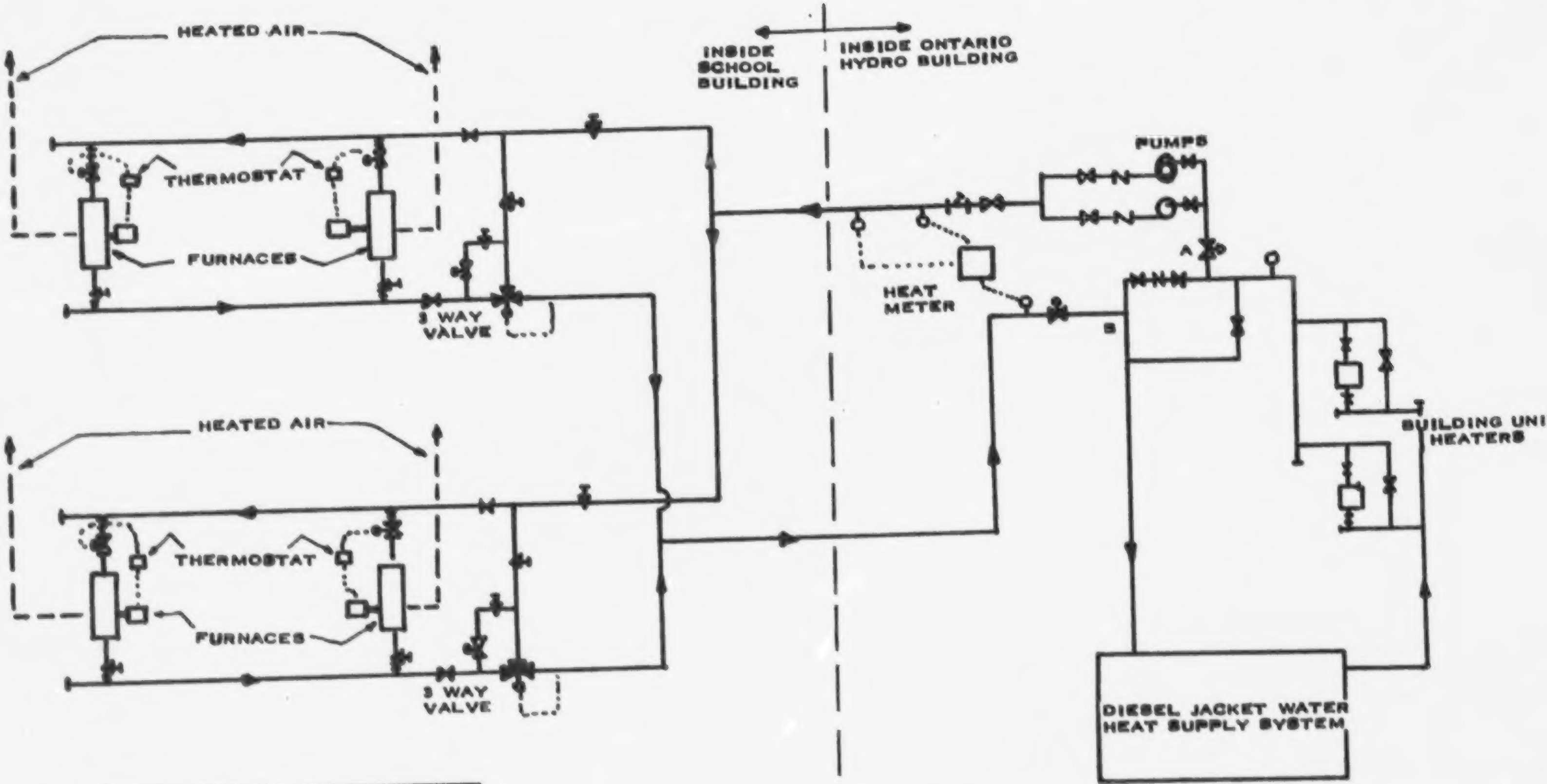
Figures 18 and 19 provide details of the basic heat recovery and supply system. Figure 18 shows the basic pipeline route. Figure 19 shows the simplified design details.

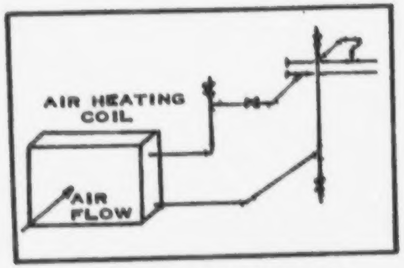
As with the other diesel heat applications, it is assumed that the basic jacket water heat supply system would be in place. The system design for the supply of excess heat to the Sandy Lake School would thus only include that equipment from the take-off point A, to the return point B, plus some incremental changes to the basic jacket water heat supply system.

The 50/50 ethylene glycol/water (aternatively 50/50 propylene glycol/water) heat transport medium would be taken off from the basic jacket water heat supply system at point A. Two centrifugal pumps would be tied to the basic system controls such that the necessary diesel engine coolant temperatures would be maintained. Below 76°C at point A, the system controls would prohibit circulation of engine secondary circuit coolant to the external heat supply loop. The two pumps are designed to supply 3.5 L/s at 324 kPa and 1.9 L/s at 112 kPa. The pumps require 2.25 kW (3 HP) and 0.75 kW (1 HP) motors respectively.

FIGURE 18
SANDY LAKE
PIPELINE LOCATION
HOT WATER DELIVERY
AND RETURN







FURNACE HEATING COIL

FIGURE 19
DIESEL HEAT TRANSPORT AND
DISTRIBUTION SYSTEM
SANDY LAKE SCHOOL APPLICATION

A heat measuring device similar to that discussed in the Section 3.2.1 on Big Trout Lake is utilized.

The supply and return pipelines between the Ontario Hydro and Sandy Lake School facilities are pre-insulated steel pipe, such as RICWIL Steelguard. The pipelines are buried side by side 1.8 m deep. The trench is filled as in Figure 11 in Section 3.2.1. As with Big Trout Lake, individual sections (up to 6 metres) are coupled using quick connect O-ring type joint.

Inside the Ontario Hydro and Sandy Lake School buildings, welded black steel pipe and fittings, insulated as required, are used. Balance and gate valves are utilized to balance line losses to individual furnaces.

Three-way diverter valves are critical components at each furnace room inlet. The temperature controlled valves regulate the amount of heating medium bypassed around the heaters to maintain satisfactory return temperature. These units must respond satisfactorily to the heating demands at low heating medium flows. At minimum flows, it is desirable that flow be concentrated to one furnace room.

At each furnace, the heating medium is fed to a 0.6 m x 1.07 m heating coil. This coil is designed for a 11.1°C heating medium temperature drop at 160 L/s for a corresponding 47°C (18°C to 65°C) air temperature rise at 1.4m^3/s.

The heating coil imposes an additional 0.085 kPa pressure drop on the furnace fan. As a result, increased fan speed and power are needed. An additional 0.23 kW of motor power is drawn per furnace.

3.4.2 Economic Assessment of Heat Supply

As for the other jacket water heat supply cases reviewed, significant pieces of data needed for an accurate economic assessment are unavailable, including:

(a) Data on current and anticipated electricity generation patterns; daily, monthly and yearly.

(b) Data on heat use patterns.

(c) Data on potential future community facilities energy requirements and fuels.

(d) Accurate fuel price and discount rate forecasts.

This missing information requires that educated estimates be made.

Electrical and Heat Load Estimates

The heat load estimates for the Sandy Lake School are highly variable. As a result, the estimated monthly consumption figures are equally uncertain. For the purposes of this study, two estimated annual heating fuel oil consumption figures were studied for both one furnace room and two furnace room diesel heat supply cases: 36,900 L/a per furnace room and 55,000 L/a per furnace room. The monthly consumptions were assumed proportional to the monthly degree day figures.

The estimated electrical load distribution was equally uncertain. The same distribution was used as described in Secton 3.2.2 for the Sandy Lake MTC diesel heat feasibility assessment. As previously, no data on the assumed distributions is provided due to their somewhat tentative nature.

Four base cases are assessed. Two one furnace room supply cases are examined: a low heating oil consumption case where 90 percent of 36,900 L/a of heating oil is saved, and a high heating oil consumption case where 90 percent of 55,000 L/a of heating oil is saved. Two two-furnace rooms supply cases are also examined: a low heating oil consumption case where 75 percent of 73,800 L/a of heating oil is saved, and a high heating oil consumption case where 75 percent of 110,000 L/a of heating oil is saved. The amount of installed oil heating capacity that can be displaced by diesel heat use is limited by the diesel heat quantity available from the diesel generator. The amount of energy supplied takes into account the potential for diesel heat recovery and supply system disruptions.

Capital Costs

The capital costs of the installed system for a one furnace room supply as described briefly in Section 3.4.1 for an in-service date of Janaury 1985 are as follows:

	Material	Labour	January 1985 $
Heat Transport System	194,920	52,520	
Building Facilities			
• Pumps and Motors	4,160	1,160	
• Heating Coils/Ducting/	5,030	3,125	
• Thermostats	670	50	
• Three-way Valves	2,030	100	
• Piping/Valves/Fitting	8,965	4,825	
• Misc	840	855	
• Glycol	18,990	-	
Sub-Total	235,605	62,645	298,250
Sub-Contractor and Contractor Overhead and Profit			88,460
Labour Travel and Expenses			13,505
Contingency/Freight/Engineering			147,950
Sub-Total			548,165
Interest During Construction			21,145
Total Capital Cost (1985$)			567,310

For the case of supply two furnace rooms, an additional cost of approximately $30,000 is required. Thus the total two furnace rooms case capital cost would be $597,310.

It should be recognized that there has been no capital cost component included for the basic jacket water heating supply system. If such a system had to be designed and installed and charged to an external heat user, the additional capital cost could approach $80,000 plus.

O&M Cost

Operating and maintenance costs in 1985$ for the system were evaluated on the basis of increased furnace fan and pump motor energy requirements, a percentage of equipment capital cost and an allowance for maintenance personnel travelling and living expenses:

	1985$	
	1 Furnace Room Case	2 Furnace Room Case
Additional Furnace Fan Motor Energy .... @ 41¢/kWh	$ 935/a	$ 1,870
Additional Circulating Pump Motor Energy .. @ 41¢/kWh	$5,031/a	$12,320
Equipment O&M ...... 1% of Capital +		
Mtce Personnel Travelling/Living Expenses	$8,130/a	$ 8,650
Total 1985 O&M Cost	$14,096	$22,840

Sandy Lake School Heating Oil Savings

As mentioned previously, four cases are examined:

	1 Furnace Room Supplied		2 Furnace Rooms Supplied	
L/a Heating Oil Saved	33,210	49,500	55,350	82,500
1985$/a (@ 69.3¢//L)	$23,000	$34,300	$38,359	$57,175

Life Cycle Present Worth Project Cost

Based on the 1985 capital, operating and maintenance, and fuel saving cost data developed and the fifteen years escalation and interest data in Appendix B, the following 15 year life cycle present worth project costs were developed. No retirement values were assumed for system components as a result of the uncertainty regarding system life. A negative life cycle present worth project cost indicates a life cycle present worth project saving. This indicates that the project would be feasible provided a 15 year pay-back at the assumed interest rates is acceptable to the parties involved.

TABLE 4

15 Year Life Cycle Present Worth Project Cost

Sandy Lake School Diesel Heat Supply

Cost Component	1 Furnace Room Cases 33210 L/a Fuel Saving	49500 L/a Fuel Saving	2 Furnace room Cases 55350 L/a Fuel Saving	82500 L/a Fuel Saving
1985 Capital	567,310	567,310	597,310	597,310
LCPW 1985 O&M	145,244	145,244	237,412	237,142
LCPW 1985 Fuel Cost	-258,520	-385,532	-431,155	-642,647
15 Year LCPW Project Cost	454,034	327,022	403,567	192,075

Figure 20 presents a year by year present worth project cost summary. Slightly lower initial capital costs are assumed. These values represent compromises between base case values and more optimistic sensitivity cases. It clearly illustrates the pattern of the LCPW Project Cost with time. None of the base cases approaches the break-even point within the 16 year period illustrated.

Figures 21 and 22 present a similar year by year present worth project cost summaries for the one furnace room and two furnace room cases respectively, but includes a high fuel oil escalation and a low discount rate alternative scenario (Appendix B) for each. As before, somewhat lower initial capital cost values are utilized. None of the cases reaches the break-even point after 16 years, but the two furnaces case, 75 percent of 110,000 L/a, is by far the closest, as one would expect.

The large distance from the diesel generator building to the school, 1204 m, is the major reason for the high project cost. For the purpose of enabling the results to be assessed for other situations, Figure 23 was prepared. It illustrates the approximate effect of distance on the 15 year life cycle present worth project savings. Distance, as expected, has a very real effect on project viability.

Brief consideration was given to the idea of relocating an existing diesel generator station close to the school. Figure 23 would seem to indicate that the economics could be favourable. It does not however take into account the additional costs to relocate the facility and the additional fuel handling charges. Taking the approximate values of these charges into account, the scheme would not be viable even at very close distances.

FIGURE 20
DIESEL JACKET WATER HEAT RECOVERY AND SUPPLY TO SANDY LAKE SCHOOL

BASE CASE ESTIMATES
ONE AND TWO FURNACE ROOM CASES

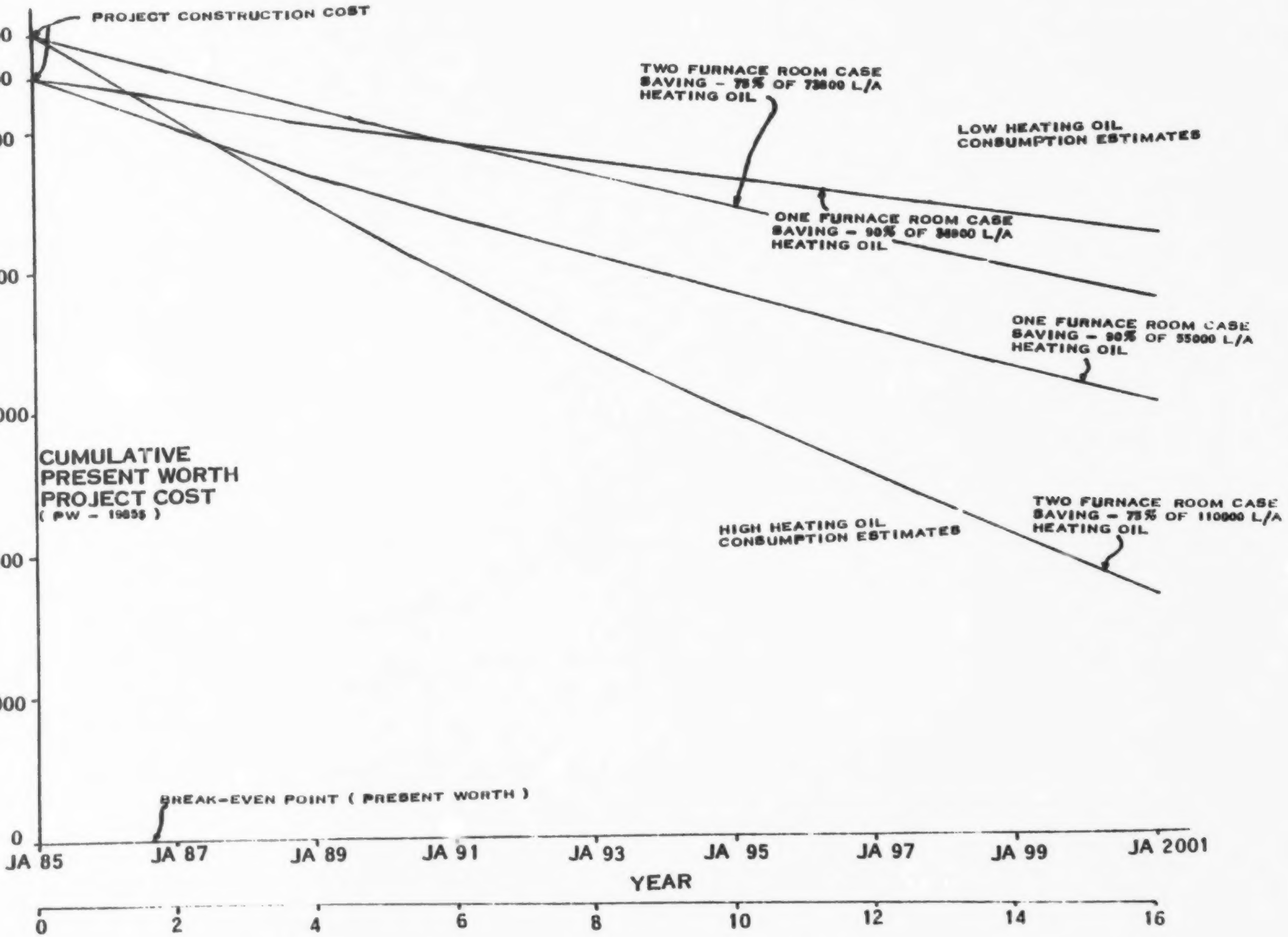
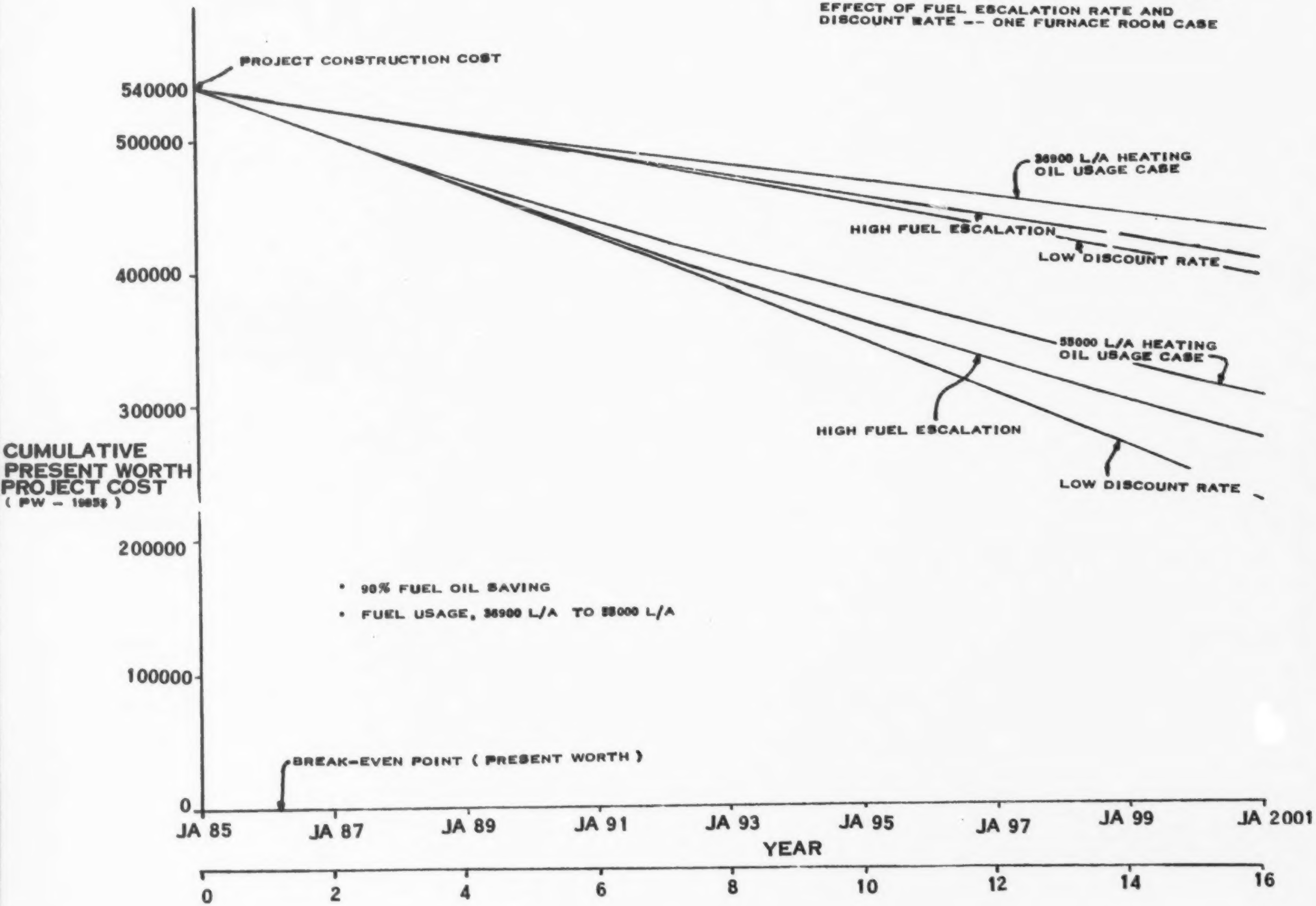


FIGURE 21
DIESEL JACKET WATER HEAT RECOVERY AND SUPPLY TO SANDY LAKE SCHOOL

EFFECT OF FUEL ESCALATION RATE AND DISCOUNT RATE -- ONE FURNACE ROOM CASE



- 90% FUEL OIL SAVING
- FUEL USAGE, 36900 L/A TO 55000 L/A

3.4.3 Project Implementation

The major issue to be resolved before a project could be implemented is its economic infeasibility. Factors common to the other similar projects considered in this study would also apply, but the overall economics of this situation is the controlling factor.

4.0 WOOD BASED ELECTRICITY GENERATION

4.1 Assessment of the Technology for Wood Use for Electricity Generation

At the present time, three major alternatives are generally considered when discussing small scale generation of electricity from wood fuel:

(a) Direct wood combustion in a steam raising boiler, with the steam used to drive a steam turbine generator.

(b) Direct wood combustion in a steam raising boiler, with the steam used to drive a steam engine generator.

(c) Wood gasification and gas clean-up, with low Btu wood gas use in a modified internal combustion engine.

Wood Boiler/Steam Turbine

A rough schematic of a wood boiler/steam turbine arrangement is shown in Figure 24. Wood chips, whole pieces or sawdust, is either hand fed or automatically fed by a conveying system. The wood may or may not be dried. The choice affects the size and type of boiler/furnace.

Either a fire tube boiler or a water tube boiler may be utilized (Figure 25, 26). Generally for small, low pressure, dried fuel applications a packaged fire tube boiler is preferred. For larger, higher pressure and wetter fuels, a packaged water tube boiler may be desirable. In either case, steam pressure has a significant effect on boiler internals complexity. Generally, for small remote applications, 1725-1825 kPa (235-250 psig) is the perceived sensible steam pressure limit.

Steam turbines are available in many different configurations and sizes; each affecting the unit efficiency and cost. In addition, the unit may be non-condensing, exhausting steam to atmosphere, or condensing, using cooling water to condense exhaust steam to water for recycle. Condensing units may be near atmospheric pressure or operated at different levels of vacuum. Each affects unit efficiency and operational complexity and cost.

In the unit sizes up to 500 kW which would be most likely in most remote communities, small single stage, single nozzle turbines would dominate. These are relatively inexpensive machines, but also very inefficient. Variations can be purchased which can both double unit cost and efficiency. Generally speaking, for a 1725 kPa (235 psig) inlet pressure and a condensing atmospheric pressure exhaust, the best efficiency (steam to electricity) one might experience is approximately 8.6 percent or 17.7 kg/KW.h of steam. For a 71 kPa absolute condensing exhaust pressure, this would increase to 9.7 percent or 15.0 kg/KW.h.

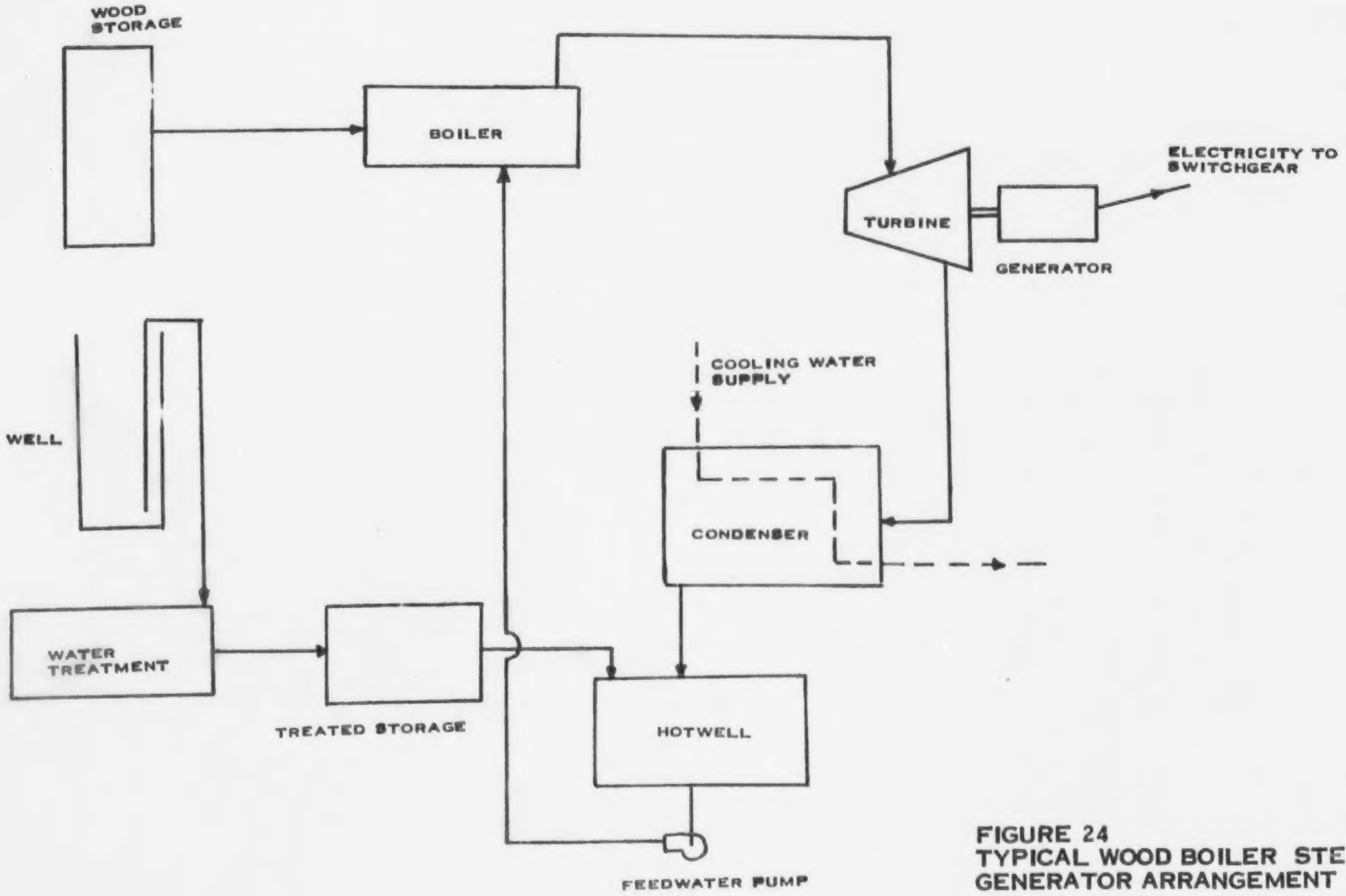


FIGURE 24
TYPICAL WOOD BOILER STEAM TURBINE GENERATOR ARRANGEMENT

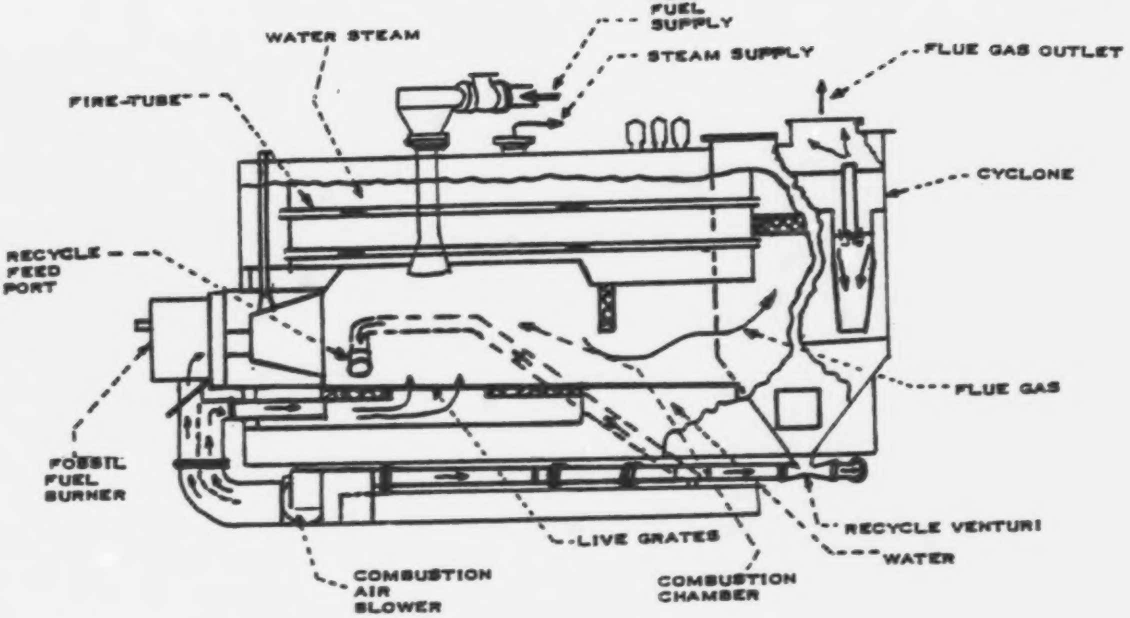


FIGURE 25
TYPICAL FIRE-TUBE PACKAGE WOOD BOILER

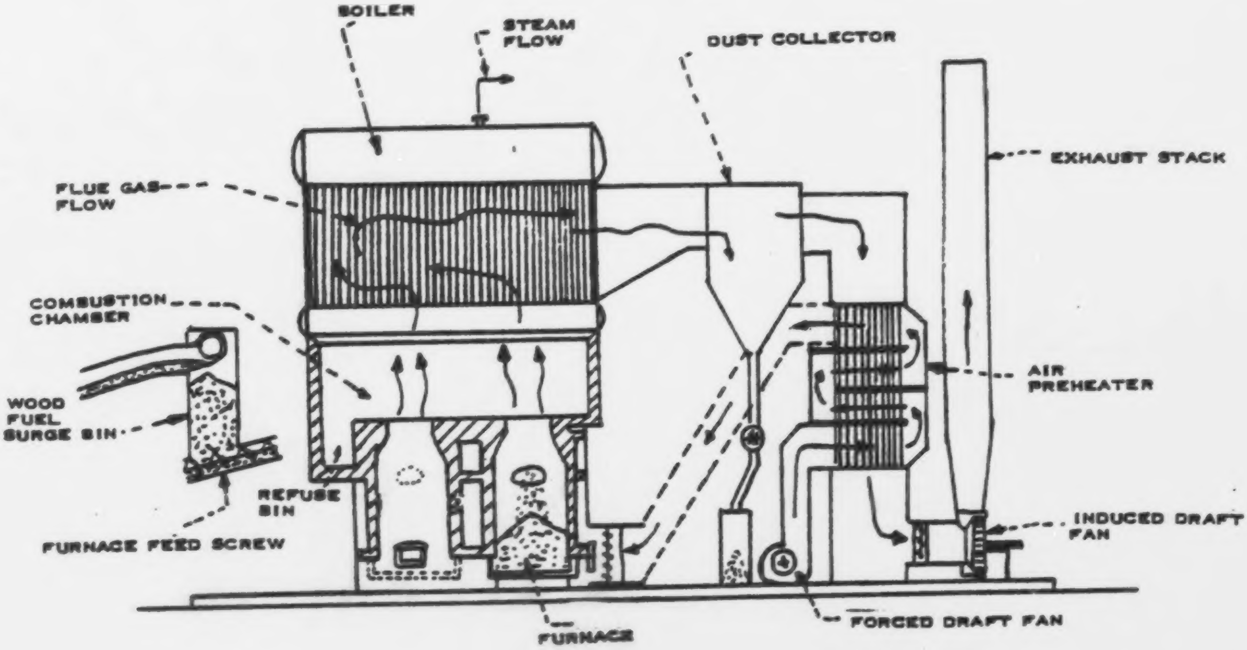


FIGURE 26
TYPICAL WATER TUBE PACKAGE WOOD BOILER

Simplicity is the key to remote site operation. Atmospheric steam exhaust would generally be the preferred route. However, cold weather exhaust vapour freezing, the cost of feedwater treatment and the general lack of good water makes this difficult for most installations.

In order to meet simplicity requirements, but preserve water and reduce costs, an atmospheric or near atmospheric condensing application is generally the preferred route. It costs the operation a penalty in efficiency compared with high vacuum operation, but avoids the additional complexity which could be a problem in a remote site. Should initial atmospheric operation prove successful, it may be desirable to implement high vacuum operation at a later date.

Wood Boiler/Steam Engine

A rough schematic of a wood boiler/steam engine arrangement is shown in Figure 27. As with the previous alternative, wood can be fed either automatically or by hand or both in either chip, sawdust or whole piece form or in some combination.

The choice of boiler design is the same as for the steam turbine case. Generally, steam engines operate at pressures in the 690 to 1035 kPa gauge (100 to 150 psig) range. Firetube package boilers are most common. Although steam engine units are available to use higher steam pressure, they are unusual. The additional boiler capital cost resulting from increased structural requirements is also a factor.

Steam engines are available in either vertical or horizontal configurations and as counterflow or uniflow designs (see Figures 28, 29). Vertical units are generally higher speed (3500-500 rpm) units and are of a much later design. Horizontal units are usually slow speed counterflow machines of a much older design, having massive flywheels for speed stability. Counterflow engines have steam enter and leave through valves at the same ends of the piston stroke (Figure 28). This results in considerable cooling of the steam as it initially enters the cylinder. Steam consumption increases and efficiency is reduced.

Uniflow engines have steam enter at one end of the cylinder and leave at the centre of the cylinder as the exhaust parts are uncovered (Figure 29). Uniflow engines were originally designed as vacuum exhaust units. To operate at atmospheric exhaust pressure, the design of the unit has been modified to act as a hybrid counterflow/uniflow unit. The change can be relatively easily reversed. In atmospheric operation, the unit does encounter some of the inlet steam condensation problems of the counterflow engine. The uniflow is a more costly design, but also more efficient.

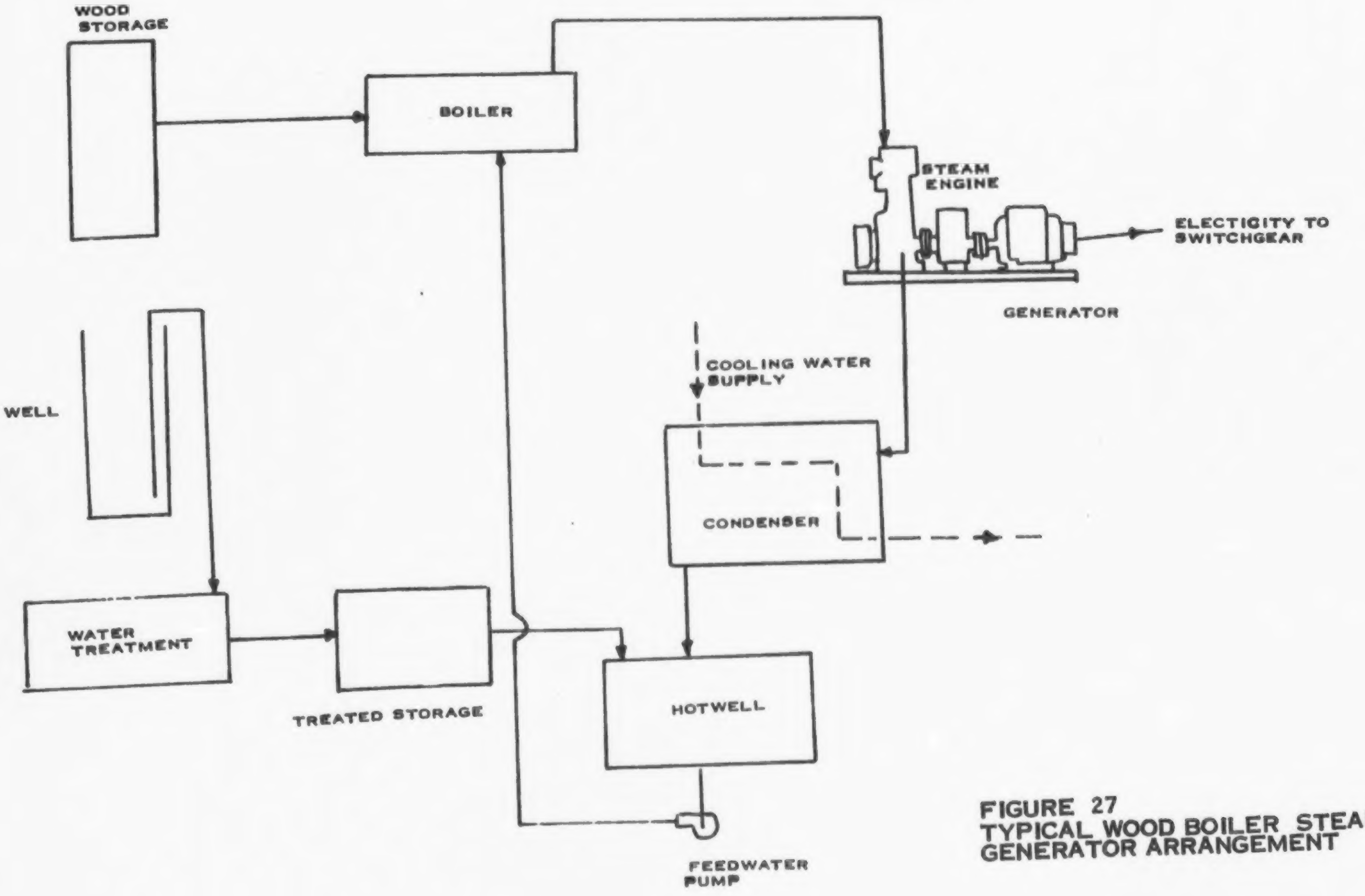
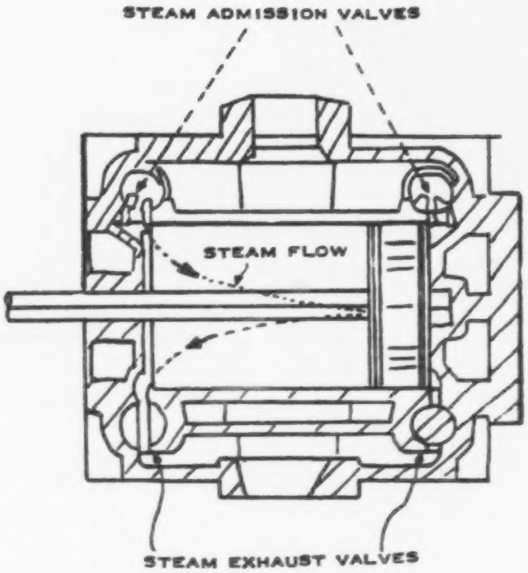


FIGURE 27
TYPICAL WOOD BOILER STEAM ENGINE GENERATOR ARRANGEMENT

FIGURE 28
TYPICAL COUNTERFLOW
STEAM ENGINE CYLINDER



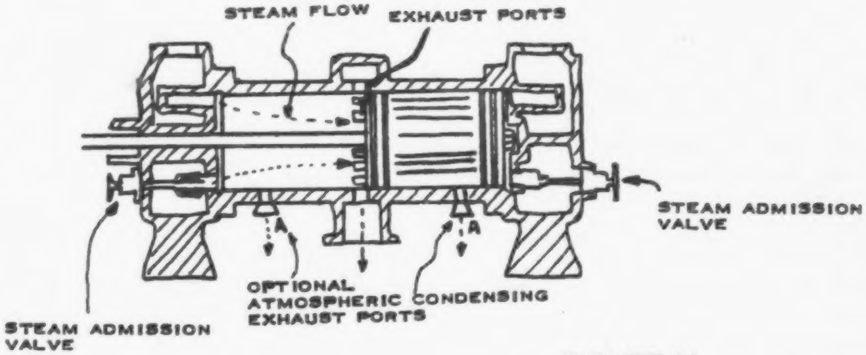


FIGURE 29
TYPICAL UNIFLOW CYLINDER WITH
OPTIONAL ATMOSPHERIC EXHAUST PORTS

Typically in a remote community, it is anticipated that an atmospheric pressure condensing unit would be utilized to keep the installation simple and to conserve water. Provision could be made to convert to high vacuum operation as operators gained experience and proved capable.

Efficiencies (steam to electricity) for typical 862 kPa gauge (125 psig) pressure to atmospheric pressure and high vacuum exhaust units are:

Engine Efficiencies
(Steam to Electricity)

	Counterflow	Uniflow
Atmospheric Exhaust	7.7%	9.8%
High Vacuum Exhaust (88 kPa Vacuum)	5.5%	13.6%

The steam engine is a much more forgiving creature than the steam turbine and will tolerate feedwater impurities and operator errors more readily. Its slow speed, lower steam pressure, and larger steam inlet clearances should mean less maintenance and less supervision will be needed. Similarly, the consequences of accidents or operator error may be less significant.

Unit cost and shipping weight and cost are major factors favouring steam turbines. Steam engines, even new high speed units, are extremely bulky and heavy, compared to their steam turbine counterparts. They are significantly more costly to purchase, transport and install.

Wood Gasification/Modified Diesel Engine

Wood gasification for use in modified diesel or spark ignition engines for electricity generation has been under investigation in numerous places by various groups, for the last five years.

Numerous spark ignition demonstration units have been undertaken in Saskatchewan, Pennsylvania, Florida, Minnesota, California, Alaska, with varying degrees of success. In all case reported, it seemed that problems with feedstock quality, wood gas tars and condensibles, generation upsets and poor reliability were encountered to some degree. In all of the relatively successful cases, a great deal of effort went into making the units work and keeping them working.

The dual fuel diesel ignition system has been deemed desirable for remote community purposes by most involved in this field. The capability to support engine operation during upsets, the potential capability of the units to handle load swings with diesel fuel, the availability of the unit as a diesel only unit, and the ruggedness, consistency and availability of the diesel itself have been sited as reasons for this preference.

Although the dual fuel diesel seems the preferred way to go, very little work has been done in North America in this area. Engine manufacturers contacted seemed to feel that the available market did not justify their development costs. Duvant and Imbert in Europe have developed units, but none have been demonstrated in North America. The Duvant unit has achieved some specific success in this area, but units are limited to a minimum of 500 kW, with limited gasifier turn-down below this. Development work on a smaller unit is ongoing. Some questions as to tar and condensible problems, as well as gas clean-up water treatment still exist.

The Ontario Ministry of Energy through a capital grant based on performance to PetroSun of Canada have an ambitious program. A used Rustin diesel engine is to be modified to operate as a 350 kW dual fuel unit in conjunction with a two stage National Synfuels wood gasifier. The unit was to have been installed, tested and running in Ramsey in early 1984. Difficulties were encountered and the economics involved have changed the initial testing site to PetroSun's facilities in Montreal. Following the completion of these trials, the unit will be shipped to Ramsey. It will supply power to the EB Eddy mill and the town of Ramsey.

The Ramsey/PetroSun project is being run as a profit oriented project. The Ontario government provided a substantial capital grant, tied to performance, and EB Eddy will purchase power at their diesel fuel cost and sell the scrap wood to PetroSun for a nominal cost. The project in Ramsey will not likely begin before November 1984.

The keys to a profitable private sector venture in a remote site according to PetroSun sources are:

(a) A large electrical demand (1,250,000 kWh/a)
(b) An automated system, with well trained staff
(c) A guaranteed supply of cheap wood fuel (6$/ODMg typically)
(d) A high diesel fuel cost.

Although three of these may be applicable, or at least attainable, a cheap wood fuel supply is not likely in most remote sites without considerable subsidy.

4.2 Assessment of Wood Use for Electricity Generation in Sandy Lake

4.2.1 Forest Resources

Preliminary forest resource data, detailed in Appendix A, for the Sandy Lake area was reviewed and some additional supplementary information collected.

A rough breakdown of the forest resources in the immediate area of the community is illustrated in Figure 30. Each block represents appproximately 2100 ODMg (2300 cords) of wood fuel available. Differences in the sizes of blocks is due to differences in density of forest, type of forest and age of forest. It is intended only as a rough guide. It was not within the original project scope to go to even this detail, however little data was available from other sources.

Several factors remain which will significantly affect the availability of any or all of this wood resource:

- Native concerns over the
  - Availability of nearby domestic wood resources;
  - environmental effects on land availability and wild life;
  - effects on native hunting, trapping.
- Reforestation capability
  - The ability and speed at which forest recovery could be accomplished in these areas of undulating bedrock, near surface bedrock under clay, and deep clay.
- Environmental effects
  - The effect of significant deforestation on future land developments, i.e., additional or reduced land moisture content, erosion, lake siltation;
  - the effects of animal habitat.
- Land use planning
  - Ontario Government's long term plans for northern development and parks, waterway and wilderness, (West Patricia Land Use Plan) Study and Royal Commission on Northern Environment.
- Ministry of Natural Resources
  - Environmental Assessment Act uncertainty regarding the need for an Environment Assessment.
- Forest fires
  - Fires which could affect the fuel feedstock available are not now controlled to the same extent in this area north of commercial timber harvesting as in more southerly locations.
- Neighbouring communities
  - Cutting outside of local community boundaries may affect the lives of neighbouring community residents and conflict with their goals.

Given the current community needs of Sandy Lake of approximately 2180 ODMg/a (2400 cords/a) and the approximately 1400 to 3670 ODMg/a (1500 to 4040 cords) needed for electricity generation, the area shown on Figure 30 could support at most initially about 70 and 40 years respectively. Given community growth and controlled forest growth, less wood would be available in the second harvest. In addition certain exclusion zones and environmental restrictions would reduce these figures further.

At some point harvesting would have to be done outside the area shown. The costs for harvesting and transporting harvested wood fuel would significantly increase. The time period available for the operation may also decrease as river or lake crossings become necessary. Neighbouring communities and the Ministry of Natural Resources may also be required to agree to harvesting outside the Sandy Lake Reserve.

4.2.2 Collection System

Two harvesting and transport collection systems were considered for this study. The first is a largely mechanized operation. The second is a labour intensive operation.

In the mechanized operation, Scenario A, trees are manually cut down using a chain saw. The limbs are then cut off and the de-limbed stems are skidded to a landing. They are chipped using a diesel powered portable chipper and blown into a converted dump truck chip van.

The chip van, equipped with weight scale, delivers the chips to the wood generation facility where it dumps the load onto a large chip pile. The chip van driver also operates the chipper.

In the labour intensive case, Scenario B, trees are manually cut down, de-limbed and bucked into four foot lengths. These are hand loaded onto one cord sleds or wagons. Four of these sleds are then collected by a tractor-dozer and transported to the wood fuel pile. The wood is manually unloaded and piled while the dozer returns to the cutting area with empty sleds. Chipping is done using a portable chipper at the generation building.

In both scenarios, several additional costs are incurred including: overheads, stumpage, road maintenance, environment assessment and reforestation.

Figure 31 presents a summary of 1984 wood harvesting costs versus harvest quantity for both the labour intensive and mechanized cases. The costs are given for base case harvesting only costs; for base case harvesting only costs plus road and environmental assessment costs; and total costs including reforestation costs.

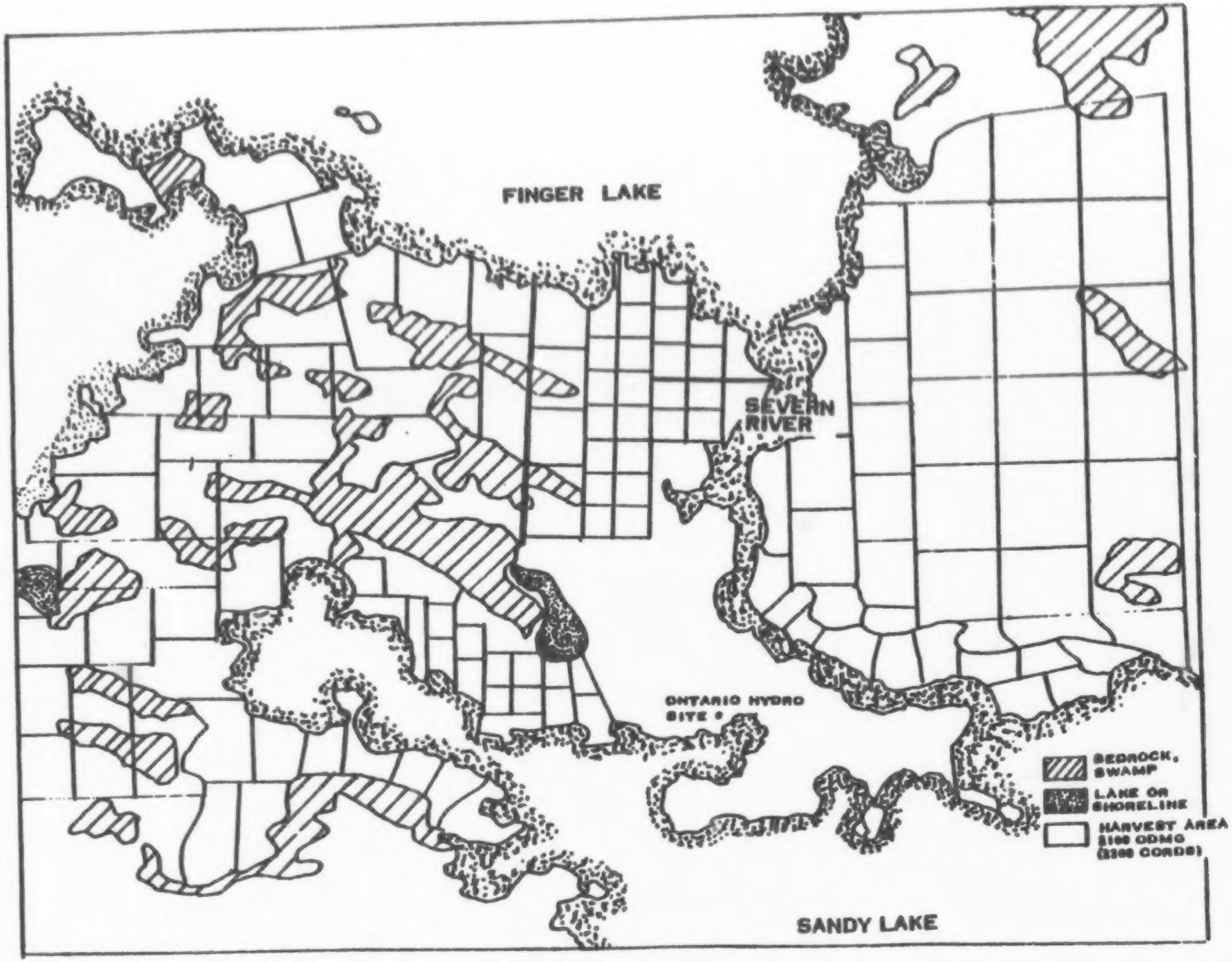
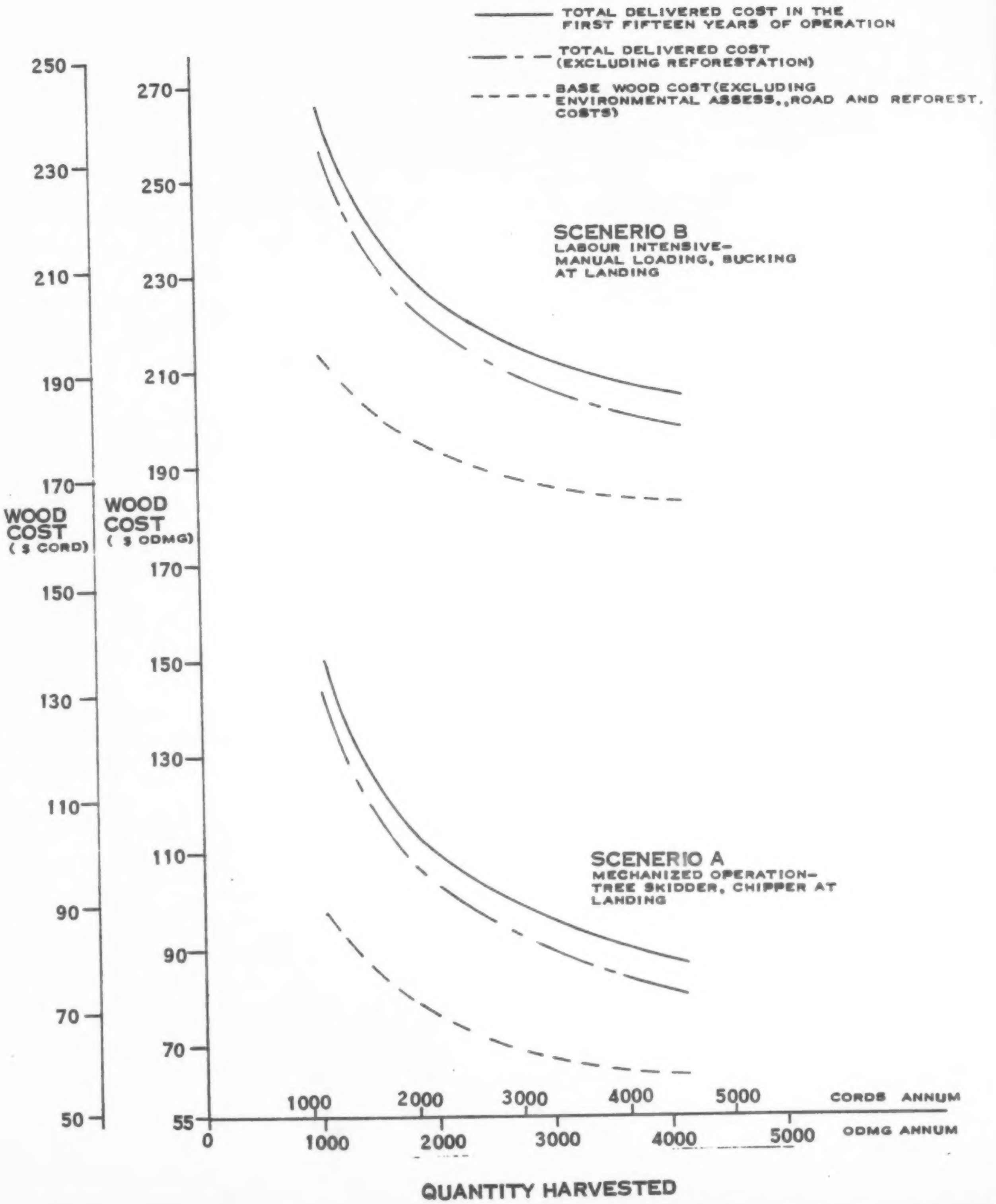


FIGURE 30
FOREST WOOD RESOURCES
SANDY LAKE

FIGURE 31
COST OF WOOD FUEL
VERSUS QUANTITY HARVESTED



Figures 32 presents a summary of labour requirements versus harvest quantity for both labour intensive and mechanized cases. The requirements are given for wood harvesting only; for harvesting plus reforestation; and for harvesting, reforestation plus electricity generation.

4.2.3 Environmental Effects

Environmental effects can be broken into two classifications:

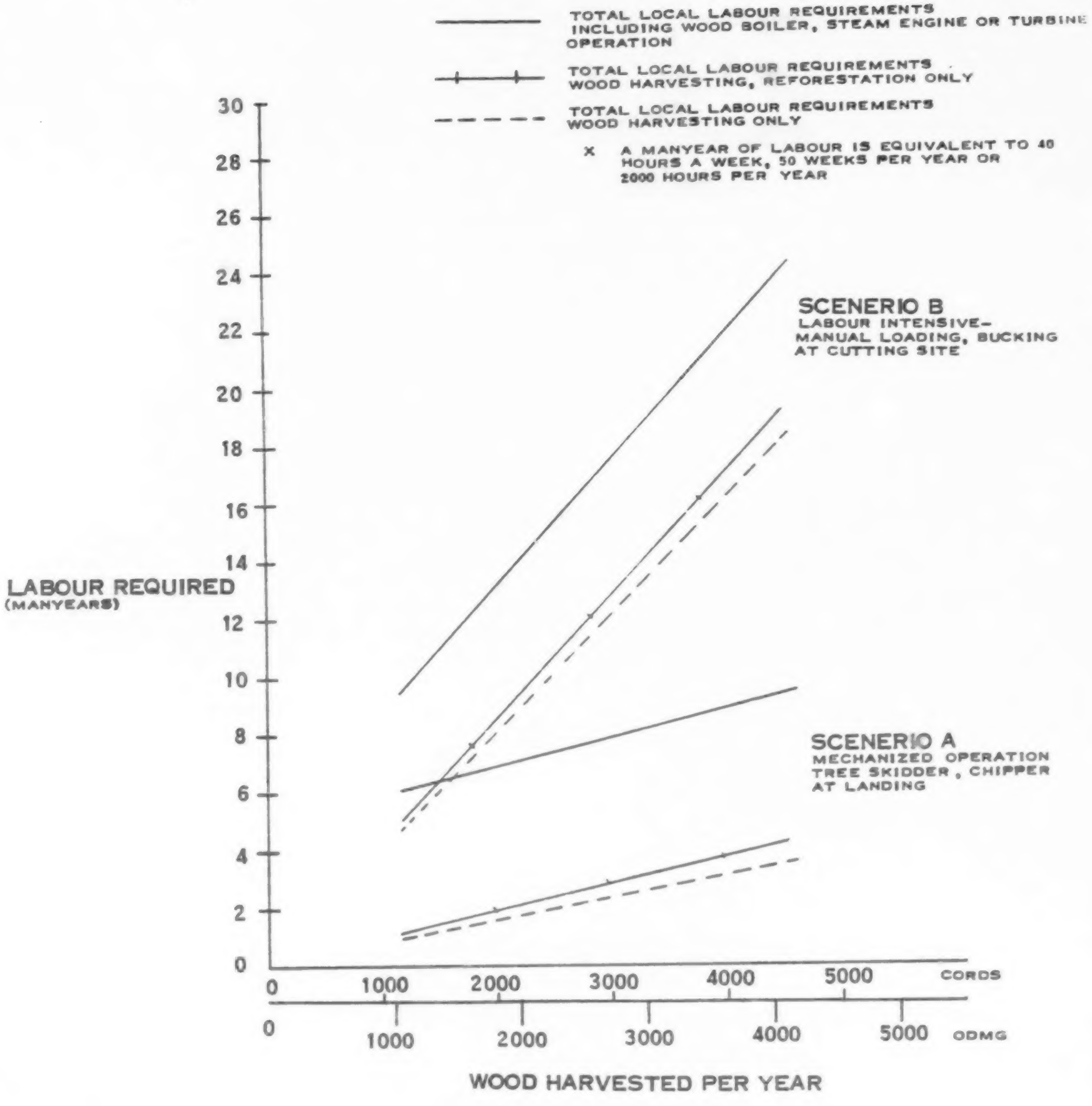
(a) Harvest related effects
(b) Generation related effects

Harvest Related Effects

Harvest related effects include:

• Silting of on surrounding waterbodies	- Care must be taken to ensure adequate cutting boundaries are maintained near waterbodies.
• Visibility effects	- Careful cutting patterns should be utilized to ensure that visual impacts of harvesting is minimized.
• Reforestation potential	- There is some likelihood that the large scale removal of forest could lead to an increase in surface water, particularly in those areas already wet. Natural reforestation could be slow and unproductive. Intensive reforestation may also face difficulties.
	- Near surface bedrock and bedrock areas could be particularly unreceptive to complete and rapid reforestation.
• Wildlife and habitat	- Extensive concentrated harvesting could over a period of years adversely affect the habitat of certain wildlife species: beaver, muskrat, fisher and marten. Although possibly advantageous to certain other species, native trapping in and around Sandy Lake could be affected. As cutting is undertaken outside the area of Figure 30, traplines of residents of other communities may be affected.

FIGURE 32
LABOUR REQUIREMENTS
VERSUS WOOD FUEL HARVEST



- Top soil damage - Tree harvesting, particularly whole tree harvesting, could damage the delicate nutrient balance in certain areas of thin top soil and subsoil. Actual physical damage, particularly in the mechanized harvesting case, could be substantial, affecting regrowth, water runoff, erosion, etc.
- Watercourses - In harvesting certain areas, precautions will have to be taken to ensure watercourses are not damaged by continuous crossings.
- Forest access - Following completion of forest harvesting in an area, road accesses will have to be closed to ensure that rehabilitation of these areas is not affected by the open access otherwise available.
- Increased community noise levels - Cutting, chipping and transport activities may lead to unacceptable noise levels in or around the community or individual residences.

Generation related effects may include:

- Visiblility Effects - A large, wood chip or log storage pile will be created in the vicinity of the existing diesel generation building which may be visibly offensive.
- Fire - The large wood storage pile and generation building would offer a much greater threat of fire due to vandalism, natural causes, or accident - appropriate precautions would be needed to ensure the safety of nearby buildings, the community and the nearby forest areas.
- Noise - Wood chipper, front-end loader operation may be offensive to nearby neighbours.

• Combustion emissions	- Based on observations of existing wood fuelled facilities, emissions to the atmosphere under normal operation should not be a problem. Grit arresters should be installed on boilers to ensure clean operation.
• Tar/condensible and oil emissions in water	- A real concern especially in the case of the gasification option. Recycling of contaminated water streams is recommended. In the case of steam engines where oil is mixed with incoming steam, an oil recovery system whereby surface oil could be sluiced off and burnt and clean water recirculated is recommended.
• Wood pile runoff	- Runoff from the wood pile will have to be examined and if necessary contained and ponded to minimize pile runoff pollution. This is not expected to be a significant problem.
• Generation noise	- Not a significant problem. Noise will be limited to the same levels as for the existing diesel generators.

4.2.4 Social Impacts

A wood fuelled electricity generation project in Sandy Lake would have significant social impacts, especially in terms of employment.

Direct full-time and part-time employment would be created in wood harvesting and at the power plant (Figure 32). Considering wood production for electricity generation only, the following would result:

(a) Harvesting - mechanized: 6 to 8 persons for 15 weeks per year
  - labour-intensive: 13 to 15 persons for 38 weeks per year

(b) Power Plant Operation: 2 to 6 persons full-time employment

In addition, several indirect employment opportunities would likely be created. Additional employment would also be possible if a community fuelwood supply were adopted.

A wood fuelled generation project may also involve other social issues which would need to be addressed including:

- The potential effects of significant increases in cash inflows to a minor segment of the community.
- The effects of environmental impacts on local trappers and hunters livelihoods.
- The effects of significant forest harvesting/transport activities on community lifestyle.

No evaluation of the significance of these issues is made here, but they should be addressed before a project of this type is committed to.

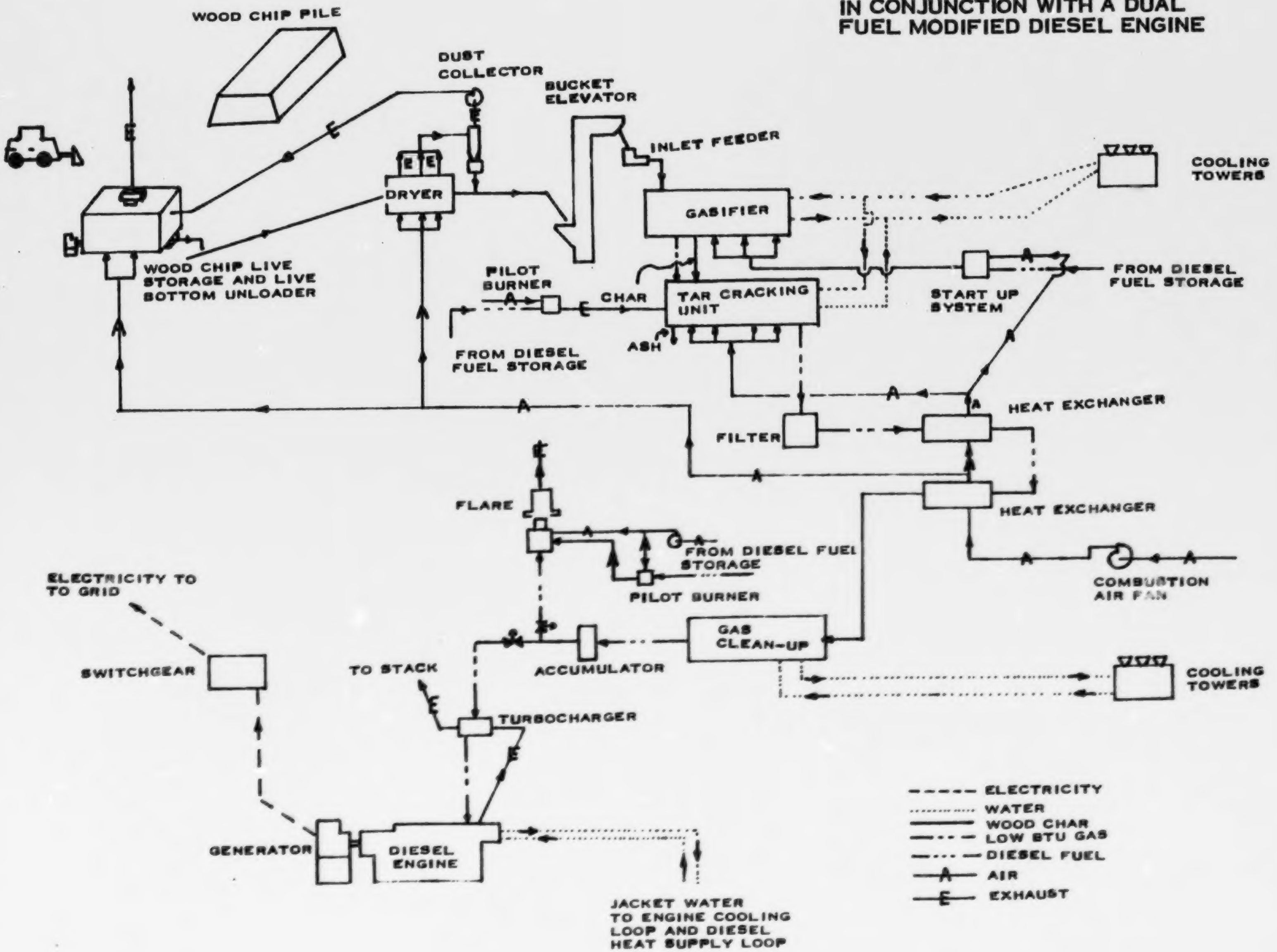
4.2.5 Wood Gasifier/Modified Diesel Engine Generator

There is currently no gasifier/engine technology sufficiently developed and proven to apply in Sandy Lake. No such demonstration is able to be undertaken with any significant prospect of success. In spite of this, an economic assessment has been conducted to evaluate its effectiveness should the technology advance.

The generic gasifier/engine design assumes a two stage gasifier, employing a gasifier and tar and condensible cracking unit similar to the PetroSun/National Synfuels design. This seems the most likely design to reduce or eliminate engine tar problems. A new modified dual fuel engine similar to the Duvant dual fuel engine, but rated at 350 kW on wood gas/10 percent diesel fuel was assumed. A smaller unit would have likely been preferable to assume a base load operation, but 350 kW is the smallest dual fuel design under development.

Figure 33 presents a rough sketch of the process flows envisioned. Considerable complexity is involved. Large scale automation is an assumed feature of the unit to simplify its operation and minimize operator requirements.

FIGURE 33
SANDY LAKE
ELECTRICITY GENERATION
USING WOOD GASIFICATION
IN CONJUNCTION WITH A DUAL
FUEL MODIFIED DIESEL ENGINE



The overall fuel requirements of the system at full load are assumed as follows:

Wood input:	7,175,400 kJ/h
Diesel fuel input:	581,000 kJ/h
Diesel energy/wood energy:	8.1%
kW output:	350 kW net

The overall wood to electricity full load efficiency is approximately 16.2 percent. At part loads the diesel input would not be expected to change in order to maintain stable operation. As a proportion of the total energy input, it would increase. Approximate values are as follows:

	75% Full Load	50% Full Load
Wood input (kJ/hr)	5,678,400	4,053,300
Diesel input (kJ/hr)	581,000	581,000
Diesel/(wood diesel) %	10.23%	14.34%
kW output	260 kW	175 kW

These full load efficiency values are goals. Based on previous wood gasification for I.C. engine use and allowing for system inefficiencies, the actual values may be lower.

Capital Cost

Given the technical status of wood gasification/internal combustion engine generator technology, an estimate of cost is difficult. For this study, the following rough estimate of the capital cost of this project in January 1985$ is provided:

TABLE 5

1985 Capital Cost
Wood Gasifier/Dual Fuel Diesel Unit

	1985$
Gasifier and Related Equipment	95,000
Tar and Condensible Combustion Unit	48,000
Engine Generator	240,000
Wood Handling and Storage	77,000
Gas Cleanup/Handling	166,000
Switchgear/Mtr Control	43,000
Utilities	15,000
Controller	50,000
Tractor Loader	30,000

Pre-Fab Building	95,000
Site Prep	30,000
Fencing	35,000
Septic Bed	25,000
Well	16,000
Fire Protection	50,000
Storage Shed	8,000
Slab/Foundation	30,000
Installation	100,000
Duty/Sales Tax	100,000
	1,253,000
Commissioning/Training	65,000
Engineering/Contingency/Freight	329,000
OH Supervision	25,000
	1,672,000
Interest During Construction	78,000
	1,750,000

This cost is significantly higher than would likely be the case in less remote sites. The remote location results in higher costs for services, installation and overheads. In particular site work and services costs are higher.

O&M Cost

Operating and Maintenance costs for the wood gasifier/IC engine alternative are highly uncertain. Several assumption sets could be employed which would significantly affect the resulting costs.

Previous wood gasifier/modified IC engine experience results in the assumption that 24 hour per day, 365 hour/day staffing is required. This is presented as operating cost scenario A in Table 6.

Alternatively it has been suggested that the automation of the plant would result in less operator hours and lower costs, approximately 4350 manhours per year or less. This is presented as operating scenario B in Table 6.

Maintenance costs for such a complex process in a remote community are highly speculative. For the purposes of this study, a reasonable figure of approximately 10 percent of installed equipment costs has been assumed. Given the complexity and the uncertainties of the process, these maintenance costs are not unreasonable relative to those for the existing diesel generators. The maintenance costs shown include the costs of the peaking diesels as well.

TABLE 6

1985 O&M Cost Comparison

Wood Gasifier/Dual Fuel Unit Versus Diesel Unit

		Wood Gasifier/Dual Fuel Unit	
		Low Operator Hours Scenario A	High Operator Hours Scenario B
	Diesel	1985$	
Operator Cost	$ 33,000	$ 85,000	$180,000
Maintenance Cost	$ 99,000	$149,000	$149,000
Total O&M Cost	$132,000	$234,000	$329,000
O&M Differential	-	$102,000	$197,000

Fuel Costs

The major factors affecting the fuel cost savings utilizing wood in place of diesel fuel are:

- The quantity of electricity generated using wood;
- The fuel efficiency of the diesel generation replaced;
- The fuel efficiency of the wood gasifier/dual fuel engine;
- The cost of the diesel fuel;
- The cost of the wood fuel.

The electricity generated by a 350 kW net wood gasifier/dual fuel engine depends on the mode of operation. It is assumed here that the wood unit would be able to take approximately 80 percent of the annual load, but also have an availability of approximately 80 percent. As a result, out of a total 1,820,200 kWh generated, the wood unit would produce 1,250,000 kWh.

The efficiency of the diesel plant in Ontario remote communities is typically 25 percent. This takes into account unknown losses, start-ups, idling, low load efficiencies etc. Under constant full load, an efficiency of 34 percent might be expected. For the purposes of this study a value of 25 percent is utilized.

The efficiency of the wood gasifier/IC engine system is 16.25 percent at full load. Diesel fuel is injected at 15 litres per hour and is more or less fixed at this minimum level at all loads. Wood gas provides the remaining input energy. It should be recognized that 16.25 percent is a full load efficiency, and does not take into account some of the losses attributed to the diesel efficiency. Since the unit will be carrying variable loads and very low loads at times, this figure would be expected to be lower on average, perhaps 12 percent.

The cost of diesel fuel as set at 69.3¢/L in 1985. This includes all taxes and transportation. Fuel escalation is at the rates given in Appendix B.

Wood fuel cost is highly uncertain. For mechanized harvesting the cost can range from $95 to $140 per ODMg depending on whether and how much of the communities requirements are harvested simultaneously. For labour intensive harvesting, the costs could range from $210 to $250 per ODMg for similar reasons.

TABLE 7

Annual 1985 Fuel Cost Comparison

Wood Gasifier/Dual Fuel Unit Versus Diesel Unit
(1,250,000 kWh)

	Diesel Unit	Wood Gasifier/IC Engine Unit	
		Mechanized Wood Harvesting	Labour Intensive Wood Harvesting
Diesel Fuel-L/a	464,684	78,790	78,790
Wood -ODMg/a	-	1,258	1,258
Diesel Fuel Cost	$322,026	$54,600	$54,600
Wood Fuel Cost	-	$119,500 to $176,120	$264,180 to $314,500
Fuel Cost Saving	-	$147,926 to $ 91,306	$3,246 to $-47,074

Life Cycle Present Worth Project Cost

Based on the 1985 capital, operating and maintenance, and fuel saving cost data and the fifteen years escalation and interest data in Appendix B, the following 15 year life cycle present worth project costs were developed. No retirement values were assumed for system components as a result of the uncertainty regarding system life. A negative life cycle present worth project cost indicates a life cycle present worth project saving. This indicates that the project would be feasible provided a 15 year pay-back at the assumed interest rates is acceptable to the parties involved.

TABLE 8

15 Year Life Cycle Present Worth Project Cost

Wood Gasifier/Dual Fuel Unit Generation

Cost Component	Mechanized Wood Harvest		Labour Intensive Harvest	
	Electricity Generation Only	Electricity Generation and Community Requirements	Electricity Generation Only	Electricity Generation and Community Requirements
1985 Capital Cost	1,750,000	1,750,000	1,750,000	1,750,000
Incremental * LCPW 1985$ O&M Cost	1,023,000	1,023,000	1,023,000	1,023,000
Incremental LCPW 1985$ Fuel Cost	-1,312,000	-1,857,000	+ 19,000	- 465,000
15 Yr LCPW Project Cost	$1,461,000	$ 916,000	$2,792,000	$2,308,000

* Includes low operator costs for wood system, operating scenario A.

The figures in Table 8 represent a realistically optimistic estimate of the cost of a wood gasification/dual fuel engine generator project. The cost of operator salaries for example could well increase if the need for 24 hour attendance were necessary. The capital cost may also be somewhat higher when all indirects are taken into account.

The effects of variations in the cost components were examined. The maintenance cost was the item with the largest degree of uncertainty. The effect of assuming no increase in maintenance costs was examined. This saved $480,000 in life cycle present worth 1985$ terms. It did not however affect the overall system economics.

Heat recovery and supply sales were briefly examined, but hold little potential to improve costs. Existing oil fuelled heating substitution opportunities are limited to those discussed earlier. These do not hold any significant net benefit. Potential future heating opportunities are uncertain and the net benefit moreso. An on-site tree nursery may be a potential application if intensive reforestation is undertaken. In this instance however, any cost saving would only at best reduce the overall cost of such a program. It would do little or nothing to improve the base economics presented herein.

4.2.5.1 Project Implementation

The major issues which would have to be resolved before a project could be implemented are:

(a) Its economic infeasibility from the point of view of the operator;

(b) Its current technical infeasibility;

(c) Native objections to large scale wood harvesting in competition with local heating requirements and to its effects on local and neighbouring community trappers and hunters.

(d) Regional Ontario Hydro plans for the automation of remote site electricity generation to improve efficiency and reliability.

Given these issues, there is no incentive for Ontario Hydro to consider further at this time a wood gasifier project in the Sandy Lake area.

4.2.6 Wood Boiler/Steam Engine Generator

A 150 kW atmospheric pressure exhaust condensing steam boiler/steam engine unit has been assumed for the purposes of this study. The unit would be base loaded; shut down only for maintenance or cleaning. Existing diesel generators would follow loads, pick up peak load changes and act as back-ups.

Upon evaluation of the limited available information on electricity demand patterns in remote communities, a very rough estimate of the potential generation from a steam powered unit was made. A power output of 850,000 kWh/annum is seen as the maximum that this unit could produce. This assumes that it would have an availability of 80 percent and be base loaded at all other times. Considerable variation could occur if maintenance requirements are more demanding or if the uncertain nature of the electric demand pattern proves incorrect.

At the present time, there is no technology related difficulty with implementing a wood boiler/steam engine generator project in Sandy Lake. The basic technology itself has been proven for over a century.

The issues to be overcome before the implementation of such a project lie largely with the nature of remote communities and of small low pressure steam cycles:

Community

(a) Limited, expensive access and transportation;
(b) Limited local skilled labour for construction and operation;
(c) Limited local business experience;

(d) Limited local materials, and machine repair facilities;
(e) Potentially limited harvesting/delivery period;
(f) Limited forest resources, competing with community home heating uses, and hunting and trapping.

Steam Cycle

(a) Inefficient simple steam cycle process;
(b) High moisture fuel.
(c) High simple cycle water requirement;

Limited access in a major difficulty. Heavy equipment such as the engine, boiler and engine flywheel cannot be flown in. Airport runway restrictions are such that aircraft such as a Hercules which have the capability to carry such loads are unable to land at those load levels.

Winter road transport is the only access to Sandy Lake for heavy equipment. The trip involves approximately 1-1/2 days. Some of the route is over gravel roads. In addition, considerable numbers of lakes, swamps, and water courses must be crossed. Access is limited to a short period of time in mid-winter. In any given year, access cannot be guaranteed.

Strong currents in Sandy Lake itself and early snowfalls have in some recent years prevented sufficiently thick lake ice formation. Early, low temperatures with a minimum of snow fall are needed to provide the ice thickness necessary to support a 9,000 to 20,000 kg truck trailer load.

Limited local skills is a second major issue. Currently, it can be difficult to find local persons to monitor and perform minor operating maintenance on diesels. To provide a steam cycle system operating 24 hours per day would require the selection and training of up to six or seven local persons as fourth or third class stationary engineers. Successful small steam cycle systems are those which have resourceful, dedicated operators. Even if units were automated to the maximum extent, operators would still be required. In addition to the actual operation of the boiler and turbine, they would be responsible for fuel supply to the conveying system.

Local operator training would require several months at stationary plants and schools in the south. Trainees would be required to pass the necessary stationary engineers examination. Regional personnel would also have to be trained in their operation and maintenance to deal with larger problems and to provide operator courses at the Sandy Lake site.

Business administration training will also be necessary if a wood based operation were to go ahead. Dealing with wood suppliers, payroll distribution and accounting, operational efficiency would all have to be overseen on site. A cost-effective management program would have to be followed.

Limited local materials and maintenance repair facilities mean that all materials must be flown in and that sufficient repair facilities must be included at the generation site. Regional maintenance staff would not be expected to bring on a regular basis the type of heavy maintenance equipment that might be needed.

The limited forest resources and potentially limited future harvesting period were discussed earlier in Sections 4.2.1 and 4.2.2.

The steam cycle/steam engine process itself is very inefficient, particularly if a user can't be found for the large quantities of waste heat. Generating electricity alone is only 5-10 percent efficient. If an open cycle cooling system were utilized, significant quantities of water would be required. Wells have not met with tremendous success in Sandy Lake and the water of Sandy Lake and nearby rivers is highly turbid. Water conservation is desirable.

Figure 34 presents a rough sketch of the process flows envisioned. Although relatively simple by electrical power generation standards, the unit is nevertheless highly complex relative to a diesel unit. Operators must have a good understanding of the various controlling parameters. Beyond just the wood unit alone, the operator would require an understanding of its relationship to the diesel units which would continue to act as peaking and back up units.

Automation is a possibility, however on-site operators would still be required by law and should be prepared to operate the system in the event of an automatic control system failure.

The full load fuel requirements of two variations of the system are presented in Table 9. System 1 represents a unit equipped with a new, medium speed, vertical, atmospheric condensing uniflow steam engine. System 2 represent a unit equipped with a used horizontal or vertical counterflow, atmospheric condensing unit.

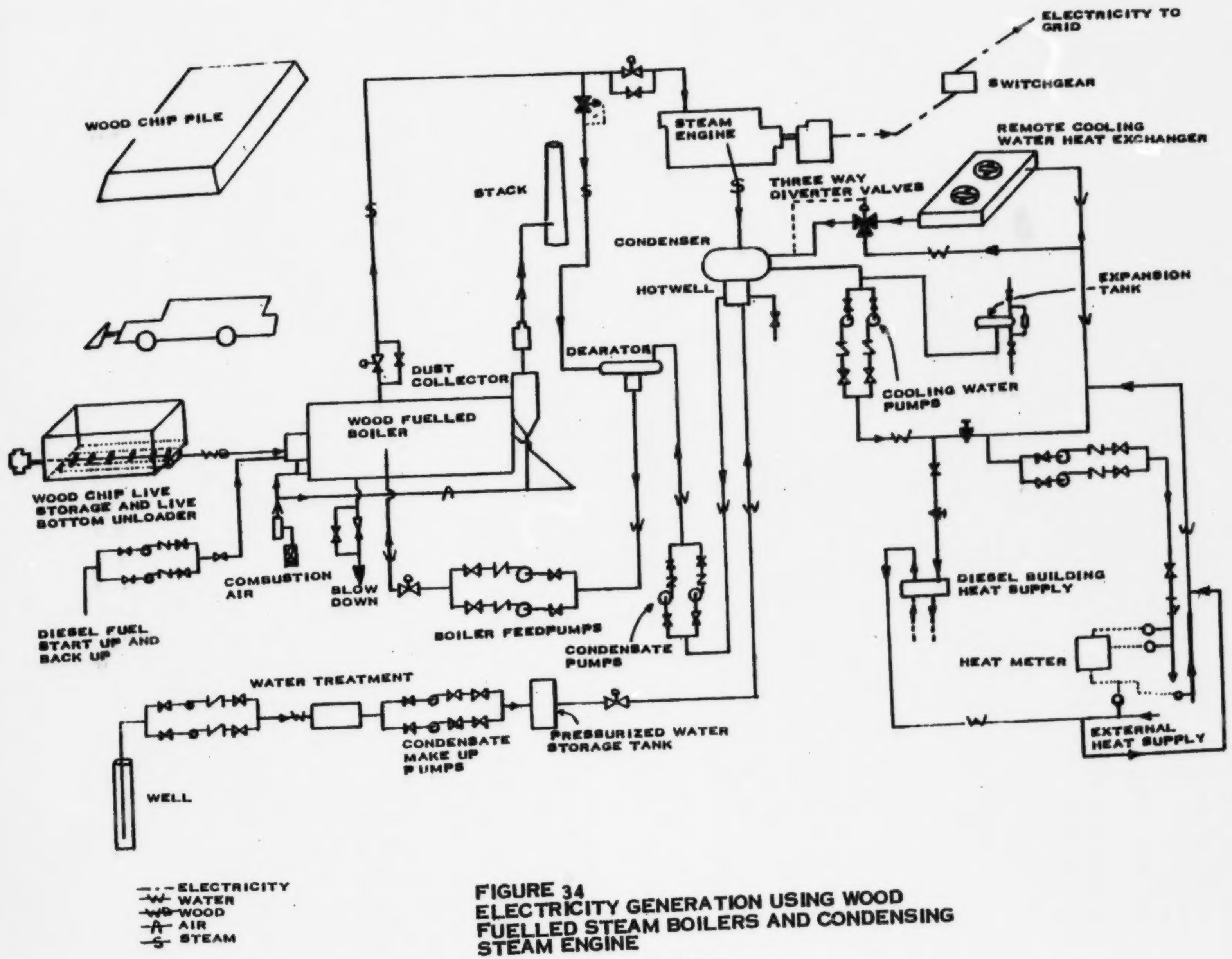


FIGURE 34
ELECTRICITY GENERATION USING WOOD FUELLED STEAM BOILERS AND CONDENSING STEAM ENGINE

SANDY LAKE, ONTARIO

TABLE 9

System Operating Characteristics
Wood Boiler/Steam Engine Systems

	System 1	System 2
kW output - net	150 kW	150 kW
- gross	174 kW	174 kW
Boiler Steam - Flow	3016 kg/h	3893 kg/h
- Pressure	1034 kPa gauge	1034 kPa gauge
Wood Fuel Requirement	0.43 ODMg/h (0.48 cords/hr)	0.56 ODMg/h (0.62 cords/hr)
System Efficiency - Percent (excluding Station Service)	7.0%	5.4%

At part loads, the uniflow unit steam requirement increases only slightly, whereas the counterflow unit requires significantly more steam. This is due to the steam flow pattern differences between the two designs and that the uniflow unit controls and reduces the quantity of steam input through the valve timing mechanism. The counterflow unit utilizes throttling to reduce steam flows, but not steam energy contents.

Capital Cost

The following preliminary estimate was prepared for two steam boiler/steam engine cases. In both the new UNIFLOW steam engine case and the used horizontal or vertical counterflow engine case, there are considerable details which would have to be refined, particularly in terms of the control system and the unit's operating relationship with the on-site diesels. There may also be some requirement to assess the capability of existing diesels to adequately perform a low load cycling/back-up role. In the case of the used engine alternative, cost factors would also vary with the type of unit, the purchase price, unit condition and unit location.

TABLE 10

Capital Cost

Wood Boiler/Steam Engine Alternative

Capital Component	January 1985$ (1000's) New Uniflow Alternative	January 1985$ (1000's) Used Counterflow Alternative
Miscellaneous Site Preparation and Systems	255	255
Wood Boiler System	370	415
Steam Engine/Condenser/Feedwater	310	165
Water Treatment	25	25
Modifications to Existing Diesels	25	25
Pumps (Incl Wiring, Supports, Etc.)	20	20
Piping, Valves, Fittings, Etc.	25	25
Basic Control System	50	50
Sub-Total	1,080	980
Contractor/Sub-Contractor Overhead and Profits	325	295
Transport Costs	40	50
Contingency	160	145
Engineering and Commissioning	160	145
Labour On-Site Expenses	95	90
Interest Charges	35	35
Total	1,895	1,740
Enhanced Control System	100	100
Total	1,995	1,840

This cost is significantly higher than would be the case in less remote sites. Installation, services, overheads and site work are all much more expensive. The cost is also higher than for the gasifier cost in Section 4.2.5. This is due to the less efficient nature of the steam cycle system, and because a few cost items included here were not included in the gasifier section. It is expected that the gasifier cost is optimistic.

O&M Cost

Operating costs for either steam boiler/steam engine case will be expensive relative to the diesel engines currently being used. Full-time operators will be required to be on duty at all times. As a result five operators will have to be trained in the operation and maintenance of these units. In addition, another full-time plant person will be required for general facility maintenance and as the fuel system operator. Basic training may also be required for several others to ensure problems do not arise due to operator sickness, retirement or termination. In the case of the diesel plants, a local resident is paid to intermittently attend to the plants needs and to provide minimal maintenance.

Maintenance costs for a steam engine system are said to be lower than for a diesel, due to the lower speed and temperatures involved. A steam engine does however require well trained, keen operators to run reliably. Further, it involves several major subsystems such as the boiler, the feedwater system, and the wood handling and feeding system which can cause improper unit operation, even unit failures. For the purposes of this study, the anticipated maintenance costs for the steam cycle system and back-up/cycling diesels are assumed higher than for the straight diesel case. The effect on life cycle present worth costs of reduced maintenance costs is examined later.

TABLE 11

1985 O&M Cost Comparison
Wood Boiler/Steam Engine Unit Versus Diesel Unit

	Diesel	New Uniflow Alternative	Used Counterflow Alternative
Operator Cost	$ 33,000	$204,000	$204,000
Maintenance Cost	$ 99,000	$124,000	$124,000
Total O&M Cost	$132,000	$328,000	$328,000
O&M Differential	-	$194,000	$194,000

Fuel Costs

As for the gasification case of Section 4.2.5, the major factors affecting the fuel cost savings utilizing wood are:

- The quantity of electricity generated using wood;
- The fuel efficiency of the diesel generation replaced;
- The fuel efficiency of the steam cycle;
- The cost of diesel fuel;
- The cost of wood fuel.

The maximum likely quantity of electricity generated by a 150 kW net steam cycle is estimated to be 850,000 kWh/annum. This assumes a base loaded operation having an availability of 80 percent. The result is an overall annual unit capacity factor of 65 percent. This is relatively high, and subject to the reliability of the unit and the capability of the operators.

Some of the remaining factors are as follows:

Diesel Generation Fuel Efficiency - 25%
Steam Cycle Fuel Efficiency - New Uniflow Case - 7%
(excluding Station Service) - Used Counterflow Case - 5.4%
Diesel Fuel Cost - $0.693/L

The wood fuel cost is dependent upon the quantities required. Table 12 presents the estimated wood quantities required and their respective fuel prices per unit and total annual cost.

TABLE 12

Wood Fuel Quantities and Costs
Wood Boiler/Steam Engine Cycle
(850,000 kWh/annum)

	Electricity Generation Only	Electricity Generation Plus Community Needs	Electricity Generation Only	Electricity Generation Plus Community Needs
NEW UNIFLOW ENGINE CASE				
- Annual Wood Quantity Required (ODMg)	2,526	4,926	2,526	4,296
- Wood Fuel Cost/ ODMg (1985$/ODMg)	$ 100	$ 85	$ 215	$ 200
- 1985 Electricity Generation Annual Wood Fuel Cost	$252,600	$214,710	$543,090	$505,200
USED COUNTERFLOW ENGINE CASE				
- Annual Wood Quantity Required (ODMg)	3,662	6,062	3,662	6,062
- Wood Fuel Cost/ ODMg (1985$)	$ 88	$ 85	$ 205	$ 200
- 1985 Electricity	$322,256	$311,270	$750,710	$732,400

Diesel generation would require 315,985 L of fuel at a 1985 cost of $218,978. Over a 15 year life cycle, the 1985 present worth life cycle diesel fuel saving would be $2,416,312.

Life Cycle Present Worth Project Costs

Based on the 1985 capital, operating and maintenance and fuel saving cost data and the 15 year escalation and interest data in Appendix B, the following 15 year life cycle present worth project costs were developed. No retirement values were assumed for system components as a result of the uncertainty regarding system life. A negative Life Cycle Present Worth Project Cost indicates a life cycle present worth project saving, indicating that the project is feasible provided a 15 year payback at the assumed interest rates is acceptable to the parties involved.

TABLE 13

15 Year Life Cycle Present Worth Project Cost
Wood Boiler/Steam Engine Generation
New Uniflow Engine Alternative

	Mechanized Wood Harvest Wood for		Labour Intensive Harvest Wood for	
Cost Component	Electricity Generation Only	Electricity Generation and Community Requirements	Electricity Generation Only	Electricity Generation and Community Requirements
1985 Capital Cost	1,895,000	1,895,000	1,895,000	1,895,000
Incremental LCPW 1985$ O&M Cost	1,906,000	1,906,000	1,906,000	1,906,000
Incremental LCPW 1985$ Fuel Cost	- 32,000	- 396,000	2,762,000	2,397,000
15 Yr LCPW Project Cost	$3,769,000	$3,405,000	$6,563,000	$6,198,000

TABLE 14

15 Year Life Cycle Present Worth Project Cost
Wood Boiler/Steam Engine Generation
Used Counterflow Engine Alternative

	Mechanized Wood Harvest Wood for		Labour Intensive Harvest Wood for	
Cost Component	Electricity Generation Only	Electricity Generation and Community Requirements	Electricity Generation Only	Electricity Generation and Community Requirements
1985 Capital Cost	1,740,000	1,740,000	1,740,000	1,740,000
Incremental LCPW 1985$ O&M Cost	1,906,000	1,906,000	1,906,000	1,906,000
Incremental LCPW 1985$ Fuel Cost	638,000	532,000	4,758,000	4,582,000
15 Yr LCPW Project Cost	$4,284,000	$4,178,000	$8,404,000	$8,228,000

Major variations in any of the wood fuelled system cost components will not have a significant effect on the overall results. Drastic changes in any of the variables would only reduce the life cycle project cost by $1,000,000 at the very most. Even in the extreme where capital was 70 percent of the above, and incremental maintenance and operator costs 50 percent of the above, wood would have to cost between $7 and $17 per oven dry megagram for the project to break even. This is not realistic.

It might be suggested that a high vacuum (14 kPa gauge) condensing operation might be more feasible. Neglecting capital and operating cost differences, the resulting wood fuel saving would be approximately $650,000/a to $1,500,000/a for the new UNIFLOW Mechanized and Labour Intensive Harvesting cases respectively and $300,000 to $700,000 for the USED COUNTERFLOW Mechanized and Labour Intensive Harvesting cases respectively. These additional savings do not make a significant impact on project feasibility.

Existing and potential waste heat opportunities do not appear to offer significant economical benefits. There would be significant quantities of heat available. However, existing facilities using oil are considerable distance away and would not offer significant savings, if any. Near term future plans do not call for any large new, heat intensive facilities. It may be that if a wood based system were available, the waste heat would be used, but it is unlikely that current planning would significantly affect the economics of the wood generation scheme.

4.2.6.1 Project Implementation

The major issues which would have to be resolved before a wood boiler/steam engine project could be implemented in Sandy Lake are:

- Its economic infeasibility from the point of view of the operator;
- Native concerns about large scale wood harvesting in competition with local heating requirements and to its effects on local and neighbouring community trappers and hunters;
- Regional Ontario Hydro plans for the automation of remote site electricity generation to improve efficiency and reliability;
- Ongoing Government of Ontario Ministry of Natural Resources Parks Planning in the area.

Until such time as these issues are resolved, it is recommended that a wood boiler/steam engine project should not be undertaken by Ontario Hydro in Sandy Lake.

4.2.7 Wood Boiler/Steam Turbine Generator

As with the wood boiler/steam engine case, a 150 kW near-atmospheric pressure exhaust, condensing wood boiler/steam turbine unit was selected. Similarly it is assumed base loaded, capable of producing about 850,000 kWh/annum. This base case assumes an 80 percent availability, which could be optimistic. Maintenance requirements may be greater due to the nature of remote communities and the lack of technically trained operators.

There is no technology related difficulty in implementing a wood boiler/steam turbine project. Boilers and turbines exist in many sizes, configurations and efficiencies. They have been proven in thousands of installations.

The difficulties in implementing a project lie largely with the nature of the communities and of small low pressure steam cycles. A list and brief discussion of some of these is included in Section 4.2.6 on pages 77 to 79.

As with the steam cycle/steam engine cycle, the process itself is very inefficient, particularly if a use can't be found for the large quantities of waste heat. Generating electricity alone is only 6.75 percent efficient (not including station service requirements). If an open cycle cooling system were utilized, significant quantities of water would also be required. Wells have not met with tremendous success in Sandy Lake and the water of Sandy Lake and nearby rivers is highly turbid. Water conservation is desirable.

Figure 35 presents a rough sketch of the process flows envisioned. Although relatively simple by electrical power generation standards, the unit is nevertheless highly complex relative to a diesel unit. Operators must have a good understanding of the various controlling parameters. Beyond just the wood unit alone, the operator would require an understanding of its relationship to the diesel units which would continue to act as peaking and back-up units.

Automation is a possibility, however on-site operators would still be required by law and should be prepared to operate the system in the event of an automatic control system failure.

The full load fuel requirements of a high efficiency steam turbine system are presented in Table 15. The turbine selected is a single stage, single nozzle unit having a high mechanical efficiency of 45.2 percent. Less expensive units are available but at greatly reduced efficiencies.

TABLE 15

System Operating Characteristics
Wood Boiler/Steam Turbine System

kW Output - Net	150 kW
- Gross	174 kW
Boiler Steam - Flow	2956 kg/h
- Pressure	1896 kPa gauge
Wood Fuel Requirement	0.449 ODMg/h (0.494 cords/hr)
System Efficiency - Percent (excluding station service)	6.75%

At part loads, the steam turbine requirement per kilowatt hour increases. The steam governing system utilizes throttling to reduce flows at reduced loads.

Capital Cost

The following preliminary estimate was prepared for a high efficiency steam turbine case. Fuel estimates and designs would have to take into account refinements in unit control system design and the unit's relationship with the on-site diesel's. It may be that a larger unit size may be compatible with the system, which although costing more, could generate a larger percentage of the power and be more economical.

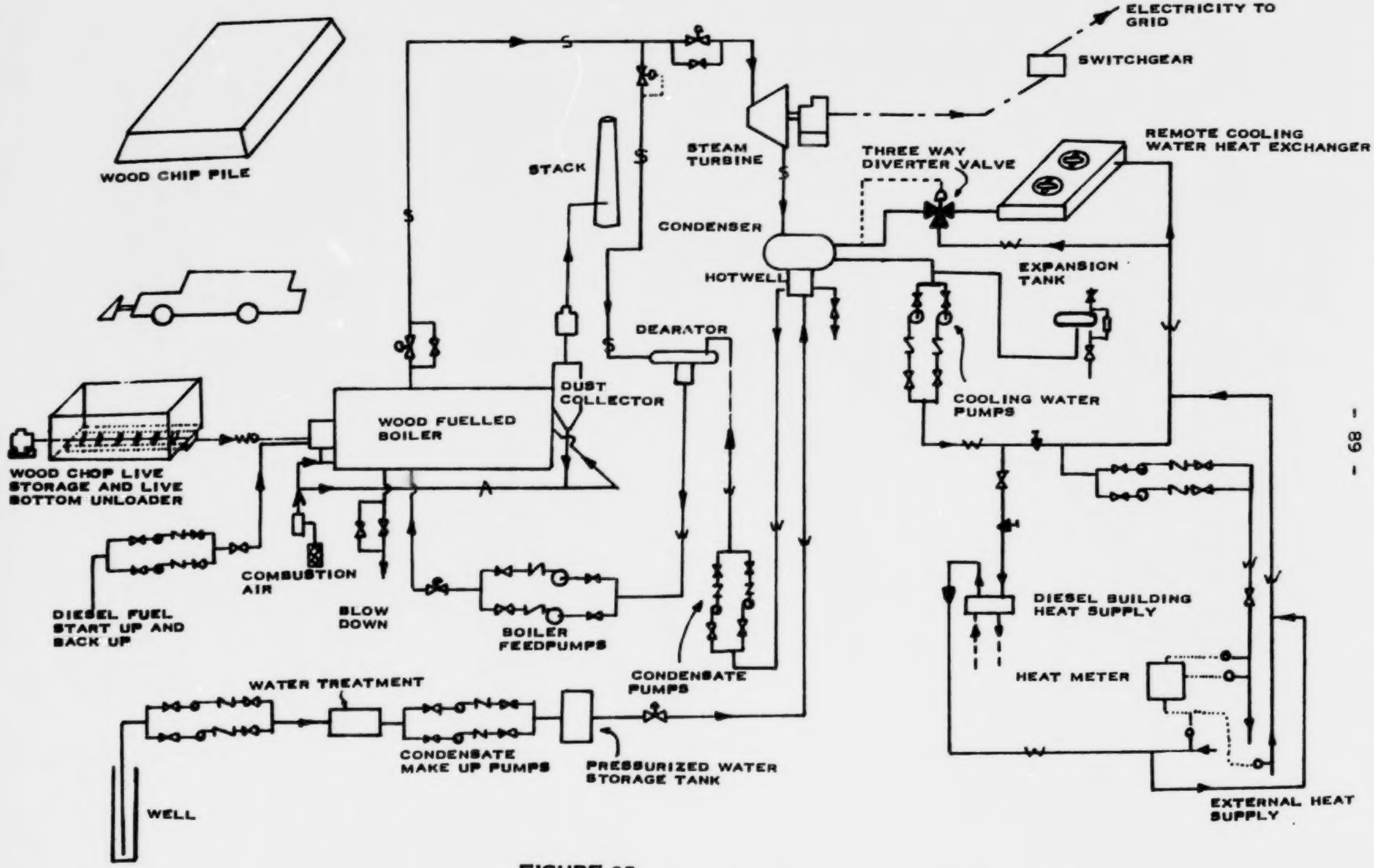


FIGURE 35
ELECTRICITY GENERATION USING WOOD FUELLED STEAM BOILERS AND CONDENSING STEAM TURBINES
SANDY LAKE, ONTARIO

TABLE 16

Capital Costs
Wood Boiler/Steam Turbine Alternative

Capital Component	January 1985$ 10^3
Miscellaneous Site Preparation and Systems	255
Wood Boiler System	430
Steam Engine/Condenser/Feedwater	210
Water Treatment	25
Modifications to Existing Diesels	25
Pumps (incl Wiring, Supports, Etc.)	20
Piping, Valves, Fittings, Etc	25
Basic Control System	50
Sub-Total	1,040
Contractor and Sub-Contractor Overhead and Profits	310
Transport Costs	40
Contingency	155
Engineering and Commissioning	155
Labour On-Site Expenses	90
Interest Charges	35
Total	1,825
Enhanced Control System	100
Total	1,925

As before, this cost is significantly higher than would be the case in less remote sites. Installation, services, overheads and site work are all much more expensive.

O&M Cost

As for the steam engine alternative, fully trained and licensed operators will be required 24 hours/day, seven days a week. This would require five full-time operators, plus a couple of trained replacements standing by. In addition, an additional person would be needed for general maintenance and fuel system operation. Special training for regional maintenance personnel would also be needed.

Maintenance costs for the steam turbine alternative should be higher than for either a diesel alternative or a steam engine alternative. The complexity of the process and the high speed operation would favour costs higher than those for the diesel. The higher speed, finer machine tolerances favour higher costs than those for the steam engine system. For sensitivity purposes, the effect of much lower maintenance costs are also examined.

TABLE 17

1985 O&M Cost Comparison
Wood Boiler/Steam Turbine Unit Versus Diesel Unit

	Diesel	Steam Turbine
Operator Cost	33,000	204,000
Maintenance Cost	99,000	135,000
Total O&M Cost	132,000	339,000
O&M Differential	-	207,000

Fuel Costs

As with both previous wood based electricity generation technologies, the major factors affecting fuel saving require definition before values can be determined. The following factors are utilized in this wood boiler/steam turbine alternative.

- Diesel Generation Fuel Efficiency - 25%
- Steam Cycle Fuel Efficiency (excluding station service) - 6.75%
- Diesel Fuel Cost - $0.693/L
- Steam Turbine Net Generation - 850,000 kWh/a

In addition, the wood fuel cost must be known. This however depends on the harvesting technique used and the quantity harvested. Table 18 presents a summary of the wood quantity used, its per unit cost and the resulting annual wood fuel cost.

TABLE 18

Wood Fuel Quantities and Costs
Wood Boiler/Steam Turbine Cycle
(850,000 kWh/a)

	Electricity Generation Only	Electricity Generation Plus Community Needs	Electricity Generation Only	Electricity Generation Plus Community Requirements
Annual Wood Quantity Required (ODMg)	2796	5196	2796	5196
Fuel Wood Cost/ODMg (1985$/ODMg)	$ 100	$ 85	$ 215	$ 200
1985 Electricity Generation Wood Fuel Cost (1985$)	$279,600	$237,660	$601,140	$559,200

Life Cycle Present Worth Project Costs

Based on the 1985 capital, operating and maintenance and fuel saving cost data and the 15 year escalation and interest data in Appendix B, the following 15 year life cycle present worth project costs were developed. No retirement values were assumed for system components as a result of the uncertainty regarding system life. A negative Life Cycle Present Worth Project Cost indicates a life cycle present worth project saving, indicating that the project may be feasible, provided a 15 year payback at the assumed interest rates is acceptable to the parties involved.

TABLE 19

15 Year Life Cycle Present Worth Project Cost
Wood Boiler/Steam Turbine Generation

	Mechanized Wood Harvest		Labour Intensive Harvest	
Cost Component	Electricity Generation Only	Electricity Generation and Community Requirements	Electricity Generation Only	Electricity Generation and Community Requirements
1985 Capital Cost	1,825,000	1,825,000	1,825,000	1,825,000
Incremental LCPW 1985$ O&M Cost	2,020,000	2,020,000	2,020,000	2,020,000
Incremental LCPW 1985$ Fuel Cost	227,000	176,000	3,320,000	2,916,000
15 Yr LCPW Project Cost	$4,072,000	$4,021,000	$7,165,000	$6,761,000

As in previous alternatives, major variations in any of the costs would not be expected to have a significant effect on the overall results. Drastic changes in any would reduce life cycle costs by $1,000,000 at best. This would not make the project any more economical.

Exhausting at a higher condenser vacuum (14 kPa gauge) is a way to achieve higher efficiencies and reduced wood consumption. The actual fuel cost savings would however be only 30 percent or $800,000 and $1,700,000 for the Mechanized and Labour Intensive Harvesting Cases respectively. This is insufficent to make the scheme economical from an operator's point of view.

Heat recovery and supply from a wood boiler/steam engine would have significant heating potential, but no ready market. Existing oil fuelled heating substitution opportunities are limited to those discussed earlier. These do not offer significant monetary benefits. Potential heating opportunities are uncertain and the benefits moreso. Little information on definite community facilities planning and heating fuel planning are available. As before, an on-site tree nursery for reforestation may be a potential application, but it will not lower the base costs in this report. It may just keep them from going any higher.

4.2.7.1 Project Implementation

The major issues which would have to be resolved before a wood boiler/steam turbine project could be implemented in Sandy Lake are:

- Its economic infeasibility from the point of view of the operator;
- Native concerns about large scale wood harvesting in competition with local heating requirements and to its effects on local and neighbouring community trappers and hunters;
- Regional Ontario Hydro plans for the automation of remote site electricity generation to improve efficiency and reliability;
- Ongoing Government of Ontario Ministry of Natural Resources Parks Planning in the area.

Until such time as these issues are resolved, it is recommended that a wood boiler/steam turbine project should not be undertaken by Ontario Hydro in Sandy Lake.

5.0 CONCLUSIONS

In reviewing the results of the work described in the previous sections of this report, the following conclusions are reached:

1. Wood fuelled steam cycle electricity generation is not economically feasible from an operators point of view in Sandy Lake or other communities having similar circumstances. Continued diesel generation, perhaps in some combination with diesel "fuel saving" techniques, is the preferred option.

2. Wood gasification with a modified dual fuel engine generator is not now technically or economically feasible in Sandy Lake or similar remote, air access only communities.

3. Current installed diesel generation equipment trends favour automation and minimal local operator interface. A wood based system would reverse this trend and require significant time and monetary expenditures to train and equip local operators and regional staff. This would face considerable opposition from Regional operations and maintenance staff in Ontario Hydro operated generating sites.

4. Diesel generator heat recovery and supply to the Bell Canada Big Trout Lake facility and to the Sandy Lake MTC airport facilities is technically and economically feasible, provided a ten to fifteen year payback period is acceptable. Similar applications such as the Pikangikum MTC airport facilities also exist and would likely be feasible, given the same criteria.

5. Several issues must be addressed and resolved before the implementation of diesel heat use.

   - the development of policies on capital cost sharing and diesel heat energy pricing;
   - acceptable investment payback criteria for public, institutional and private participants;
   - uncertainty regarding the energy requirements of and future plans for MTC airport facilities;
   - future potential heating opportunities;
   - economics of alternative renewable energy heating or energy conservation technologies.

6. Diesel generator heat supply to the Sandy Lake school is not economically feasible due to the transport distance involved. Other applications such as the schools in Pikangikum, Armstrong and Big Trout Lake, the Nursing Stations in Pikangikum, Big Trout Lake and Sandy Lake, and the CN facilities in Armstrong would also be infeasible because of distance and other complications.

6.0 RECOMMENDATIONS

As a result of the investigations and findings of this study, the following recommendations are put forth for those preparing policy and making program decisions:

1. Until the issues associated with wood use for electricity generation in remote communities are resolved, wood should not be considered by Ontario Hydro as a fuel for electricity generation in remote communities such as Sandy Lake not having large quantities of inexpensive wood fuel, easy access, and trained operators.

2. Operators of engine generator facilities should be encouraged to participate in diesel heat recovery and supply projects, taking into account transport distances, diesel heat availability and incremental operating expenses.

3. Ontario Hydro's Marketing Branch should continue their development of a comprehensive policy on remote site diesel heat sales, allowing sufficient flexibility to accommodate site specific circumstances.

4. Current and future remote site community facilities and community electrification planning should take into account the possibility of future diesel generator heat supply.

5. Discussions should be held between Ontario Hydro's Regional Marketing and Operations representatives and those for Bell Canada's and MTC's northern operations regarding the possibility of diesel heat supply in Big Trout Lake (Bell Canada), Sandy Lake (MTC) and Pikangikum (MTC).

APPENDIX A

Wood Resource and Potential Diesel Heat Recovery and Supply Assessment

Wood Resource and Potential Diesel Heat Recovery and Supply Assessment

TABLE OF CONTENTS

Page No.

1.0 INTRODUCTION 102

2.0 SUMMARY 106

3.0 SANDY LAKE 107

- 3.1 Community Background Data 107
- 3.2 Electricity Supply 110
- 3.3 Alternative Generation Opportunities 113
- 3.4 Community Heat Users 120
  - 3.4.1 MTC Airport Facilities 120
  - 3.4.2 Sandy Lake School 120
  - 3.4.3 Nursing Station 122
  - 3.4.4 Hudson's Bay 124
  - 3.4.5 Potential Applications 124
- 3.5 Community Response to Electricity Generation and Diesel Heat Applications 124

4.0 BIG TROUT LAKE 126

- 4.1 Community Background Data 126
- 4.2 Electricity Supply 130
- 4.3 Alternative Generation Opportunities 132
- 4.4 Community Heat Users 135
  - 4.4.1 MTC Airport Facilities 135
  - 4.4.2 Big Trout Lake School 136
  - 4.4.3 Department of Environment Weather Station 136
  - 4.4.4 Hudson's Bay 138
  - 4.4.5 Nursing Station 138
  - 4.4.6 Band Garage 139
  - 4.4.7 Bell Canada 139
  - 4.4.8 Potential Applications 140
- 4.5 Community Response to Electricity Generation and Diesel Heat Applications 140

5.0 PIKANGIKUM 141

- 5.1 Community Background Data 141
- 5.2 Electricity Supply 143
- 5.3 Alternative Generation Opportunities 147
- 5.4 Community Heat Users 148

Page No.

5.4.1 Hudson's Bay 148
5.4.2 Nursing Station 148
5.4.3 Pikangikum School 150
5.4.4 MTC Airport Facilities 152
5.4.5 Potential Applications 154
5.5 Community Response to Electricity Generation and Diesel Heat Applications 154

6.0 ARMSTRONG 155

6.1 Community Background Data 155
6.2 Electricity Supply 158
6.3 Alternative Generation Opportunities 161
6.4 Community Heat Users 163
6.4.1 D&L Estates 163
6.4.2 Armstrong School 165
6.4.3 MNR Armstrong Field Office 165
6.4.4 CNR Bunkhouse and Station 167
6.4.5 Armstrong Tree Nursery 169
6.4.6 Potential Applications 169
6.5 Community Response to Electricity Generation and Diesel Heat Applications 170

7.0 CONCLUSIONS 171

8.0 RECOMMENDATIONS 172

BIBLIOGRAPHY 175

CONTACTS 180

LIST OF FIGURES

Figure Number	Title	Page No.
1	Ontario Remote Communities	103
2	Location of Selected Remote Communities	105
3	Sandy Lake	108
4	Sandy Lake Reserve	109
5	Sandy Lake Aerial Photo	112
6	Sandy Lake Peak Loads	114
7	Sandy Lake Getty Mines Proposed Mine and Power Plant Site	116
8	Sandy Lake Reserve Boundary and Forest Land Requirements	118
9	Sandy Lake MTC Facilities	121
10	Sandy Lake School	123
11	Big Trout Lake	127
12	Big Trout Lake Aerial Photo	131
13	Big Trout Lake Aerial Photo	134
14	Big Trout Lake School Heating Boilers	137
15	Pikangikum	142
16	Pikangikum Airport and Diesel Facilities	144
17	Pikangikum Peak Loads	146
18	Forest Fires in the Pikangikum Area	149
19	Pikangikum Community Facilities	151
20	Pikangikum School Site Layout	153
21	Armstrong	156
22	Armstrong Aerial Photo	160
23	Armstrong Peak Loads	162
24	Armstrong Forest Resource Assessment	164
25	Armstrong School Site Layout	166
26	MNR Armstrong Facilities	168

Wood Resource and Potential Diesel Heat Recovery and Supply Assessment

1.0 INTRODUCTION

Ontario Hydro is currently providing a central diesel generator based electricity production and distribution service in 16 remote and rail communities in Northern Ontario (Figure 1). By 1987, approximately nine more communities may be supplied. The cost of the production and distribution of electricity is much higher than that produced for the power grid. The high cost of diesel fuel, maintenance equipment and personnel are the major contributors.

Alternative energy production using wood, wind, small hydraulic and solar energy as well as any means of improving energy efficiencies and costs are of particular interest to remote communities and the government agencies responsible for the servicing of these communities.

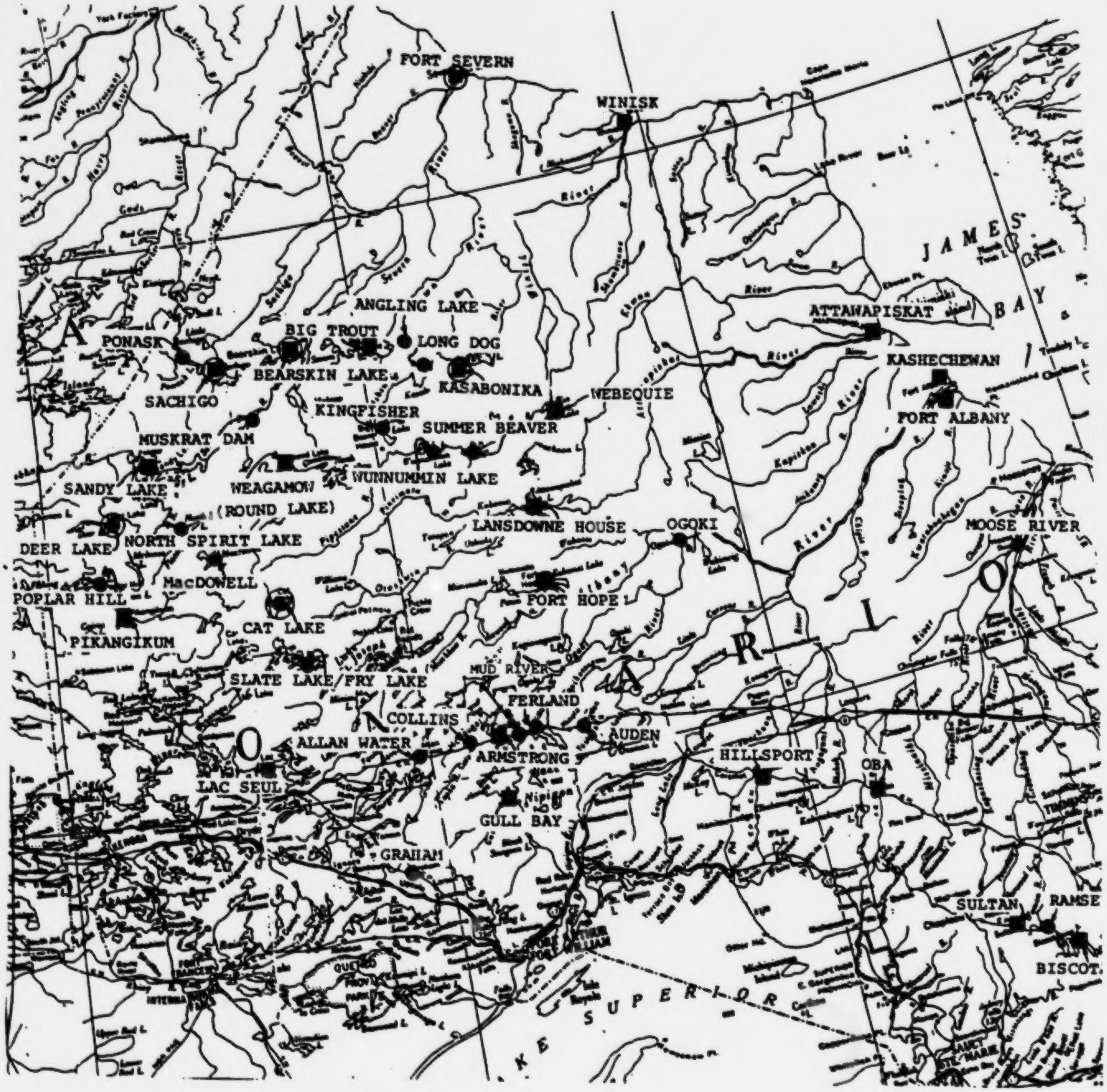
Ontario Hydro's Energy Studies Department has been actively involved in looking at alternatives to diesel generation for remote communities since 1978. Several reports have been published on the application of alternative energies in these situations. Several pilot demonstration projects have been in operation; a wind-diesel pilot plant in Sudbury, a photo-voltaic cell demonstration installation at the Kortwright Conservation Area and near Atikokan.

In 1982, studies by the Federal and Ontario provincial governments[10, 11, 15] indicated that wood based alternatives might be considered economical for remote site generation. It was felt, by personnel in the Energy Studies Department of Ontario Hydro, that a somewhat more specific assessment of the potential in detailed communities was needed, since our own preliminary studies had previously indicated that wood based systems would not be economical. Installations where heat could be recovered and used to improve the overall system economics and energy efficiency were of particular interest.

In January 1983, the Energy Studies Department applied under the Federal Government's Remote Community Demonstration Program (RCDP) for CO-funding of a study to examine the feasibility of wood based generation systems, and electricity generation heat recovery and supply. The RCDP program was established by the Federal Government in 1982. A two phase, seven year program, its aims were to establish the feasibility of alternative energies and improved energy efficiency of systems in remote communities in Canada and to provide funding for practical demonstration projects.

FIGURE 1

ONTARIO REMOTE COMMUNITIES



● REMOTE COMMUNITIES HAVING NO CENTRAL ELECTRICITY GENERATION FACILITIES OR SERVICED BY LOCAL NON-ONTARIO HYDRO DIESEL GENERATORS

■ REMOTE COMMUNITIES SERVICED BY ONTARIO HYDRO DIESEL GENERATORS

▣ REMOTE COMMUNITIES TO BE SERVICED BY ONTARIO HYDRO IN 1984/85

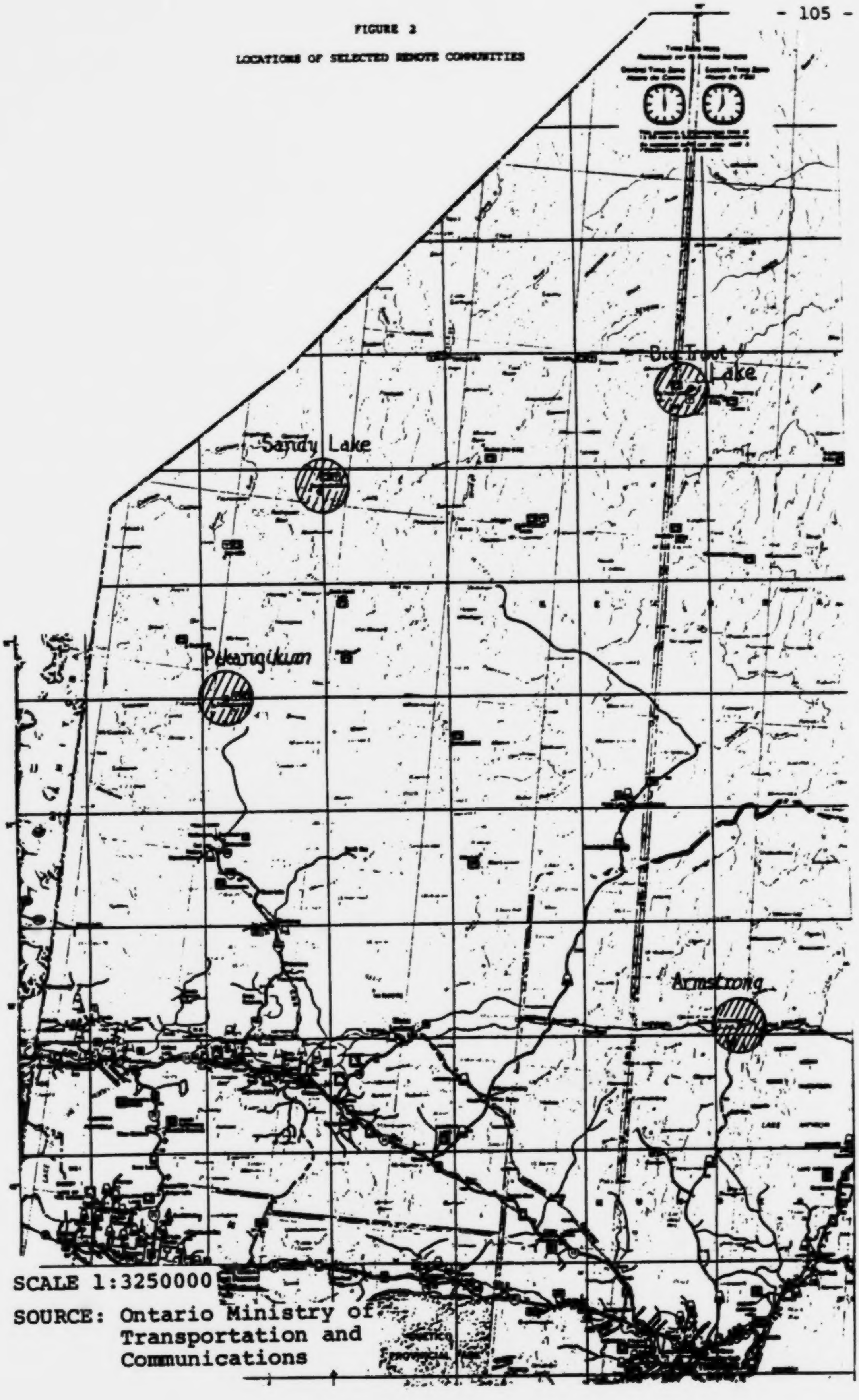
◉ REMOTE COMMUNITIES TO BE SERVICED BY ONTARIO HYDRO IN 1985/86

The Ontario Hydro proposal selected four remote communities, appearing to have potential wood and waste heat applications. This appendix documents the initial investigation of their potential for heat use from an electricity generating application and the potential for a wood based generation alternative. From this information, two communities were selected for more detailed analysis and design. Specific applications of wood use or heat recovery and use are examined and costed.

Based on preliminary information presented in reports by Middleton Associates and Ralph Hedlin Associates[10, 11], it was agreed with EMR representatives to examine the communities of Sandy Lake, Big Trout Lake, Pikangikum and Armstrong (Figure 2). The major criteria used in their selection was their population, community facilities, diesel fuel prices, potential wood availability and data availability. Armstrong was selected largely for Ontario Hydro's own interest. It is and has been the subject of numerous other studies, including another RCDP sponsored study.

FIGURE 2

LOCATIONS OF SELECTED REMOTE COMMUNITIES



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SOURCE: Ontario Ministry of Transportation and Communications

2.0 SUMMARY

Based on existing information available about the communities of Big Trout Lake, Sandy Lake, Pikangikum and Armstrong and on information collected from site visits and other sources, the potential for wood based generation of electricity and heat recovery and supply applications was assessed for each community.

Wood resources were assessed using existing forest data and some preliminary aerial photograph interpretation. Some on-ground cruising provided additional information to this assessment and a perspective on local availability. Information from Indian band and local community leaders provided insight on the communities attitude toward use of local resources.

The results of the wood resource assessment led to the conclusion that Sandy Lake and Armstrong had sufficient wood resources. In Sandy Lake's case it would be necessary to obtain a license for off-reserve harvesting.

Big Trout Lake had enough annual growth to consider a wood based generation alternative, but the band wished to reserve the best growth areas for local home heating use. The remaining areas are in many cases very poor quality. Considerable uncertainty over the effects of harvesting in these areas, on their regrowth and the environment led to Big Trout Lake being dropped from further consideration of wood use for electricity generation. Pikangikum has insufficient wood resources in the area surrounding the community as large fires decimated much of the best forest land in and around the reserve.

With respect to diesel heat recovery and supply, the closest facilities were the MTC airport facilities in Sandy Lake and Pikangikum, a Bell Canada Remote Staff Residence in Big Trout Lake and CN's facilities in Armstrong. The best other potential heat users were the local schools, but these were all located considerable distance from the generator sites.

On the basis of the data collected, it is recommended that Sandy Lake and Big Trout Lake be selected for more detailed study. Armstrong was dropped because of other studies ongoing on this community and because of existing Ministry of Energy interest[C-24] in possibly operating a demonstration wood based electricity generation project there. Further, it was felt more effort should be concentrated on native communities since these have the higher fuel costs. Pikangikum was dropped from further consideration since wood resources were unavailable, and the diesel heat use opportunities which exist are similar to those in Sandy Lake and the results would be easily transferred.

In Sandy Lake, three wood and diesel heat recovery and supply applications will be examined. The first is heat supply to the MTC airport facilities; the second is long distance heat transport to the Sandy Lake School; and lastly, electricity generation using wood as a fuel feedstock.

In Big Trout Lake, the supply of diesel heat to Bell Canada's remote site staff residence will be examined. No wood based electrical generation systems will be considered.

3.0 SANDY LAKE

3.1 Community Background Data

Sandy Lake (Figure 3) is a native community of approximately 1400 to 1500 people comprised of 240 households. It is located at the mouth of the Cobham River, and extends eastward along Sandy Lake and north towards Finger Lake (Figure 4). It is approximately 225 kilometres northeast of Red Lake and 345 kilometres north northwest of Sioux Lookout at 53°N10' latitude and 93°W20' longitude. It is accessible by air and by winter road.

Sandy Lake is the centre of the Pahabula Tribal Council. The other Pahabula communities include Poplar Hill, Pikangikum, North Spirit Lake, Sachigo, Deer Lake, and MacDowell. Pikangikum and Sandy Lake are the only ones currently serviced by Ontario Hydro. Sachigo and Deer Lake installations are currently under construction or planned. The primary languages in the Pahabula area are Ojibway, Cree and English. The Tribal Council chief, also the Sandy Lake Band Chief, is Josias Fiddler.

Sandy Lake is served by scheduled and charter aircraft using the Ministry of Transportation and Communication's airport. It features a 1077 m gravel runway with landing lights and non-directional beacon, a staff bunkhouse, a vehicle garage and a storage warehouse. Scheduled service is provided by Austin Airways and Bearskin Air.

Relative to other communities, Sandy Lake has considerable economic activity, including:

- seasonal hunting and fishing
- home construction
- band, Provincial and Federal Government Offices
- Hudson Bay, Cooperative and Private Stores

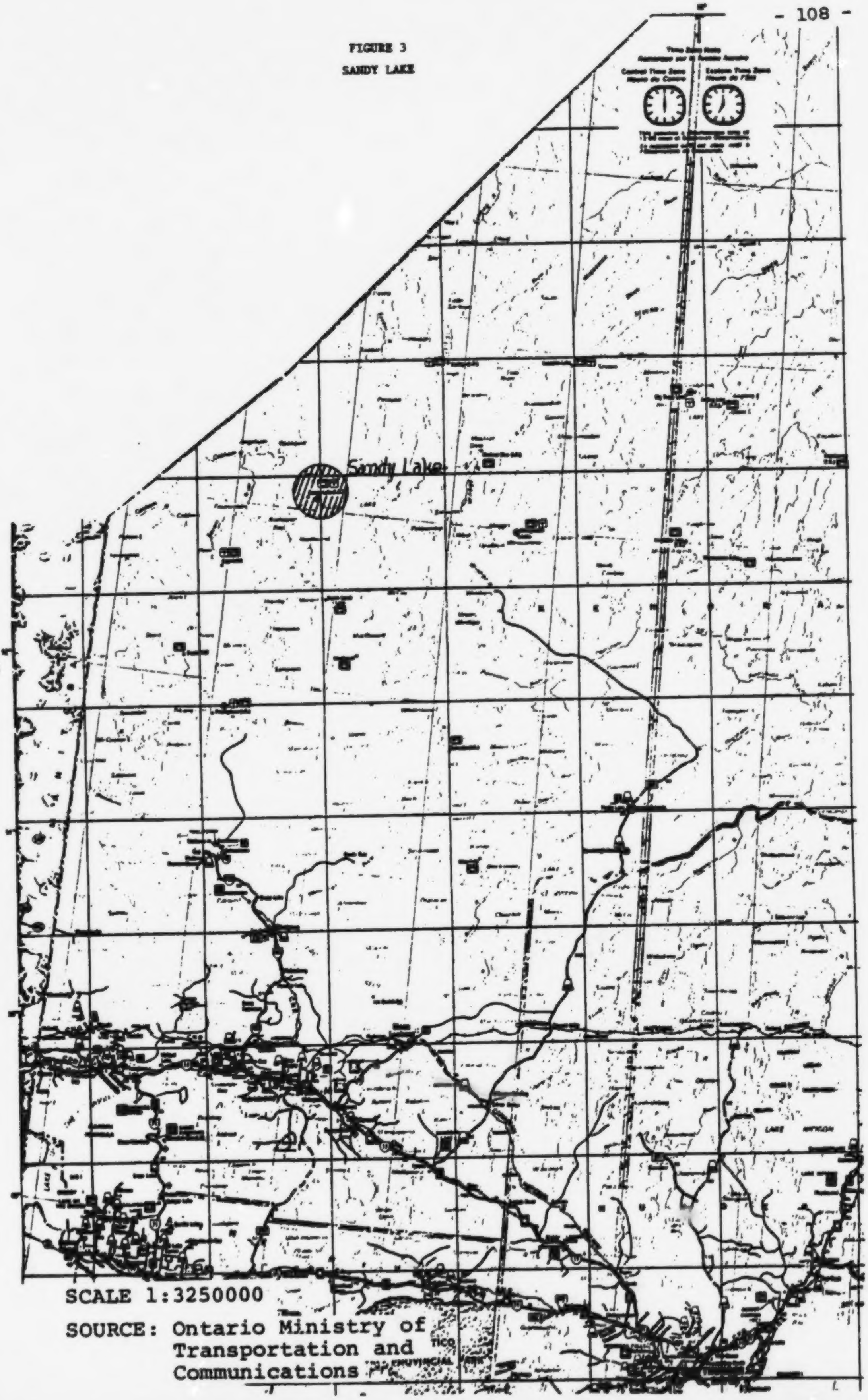
Despite this activity, there is considerable unemployment in the community. Chief Fiddler in his visit to Ontario Hydro Offices in Toronto indicated that unemployment is about 50 percent.

The major facilities in Sandy Lake are almost exclusively government related. A summary of said facilities, as taken from the R. Hedlin Associates study and verified by a site visit, is:

- Primary School, Grades 1-10
- Nursing Station
- Hudson Bay Store
- Community Hall
- MTC Airport
- Five Churches
- Two Private Stores
- OPP Reserve Police Station
- Ontario Hydro Diesel Generators
- Band Fire Station

FIGURE 3

SANDY LAKE



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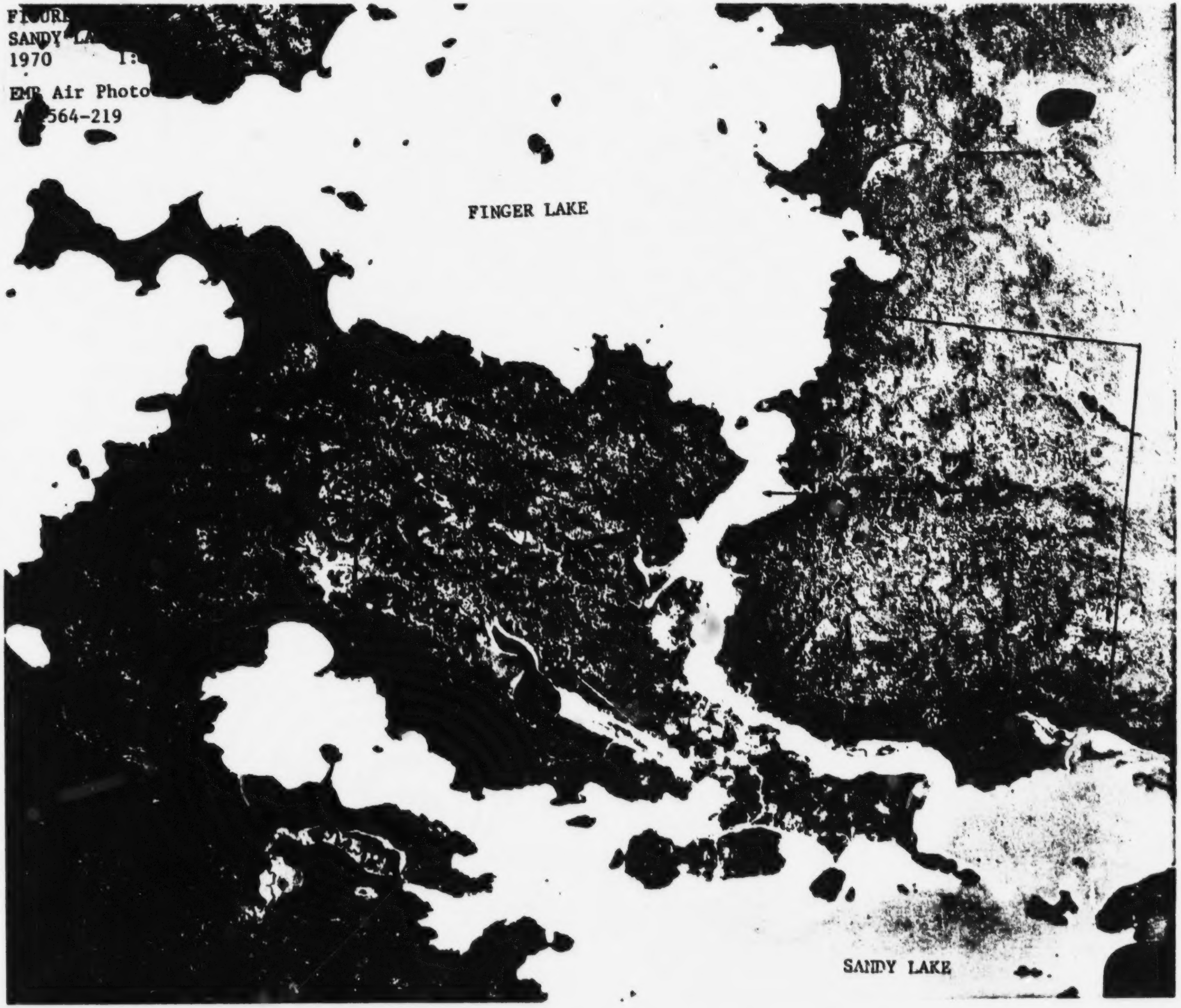


FIGURE
SANDY LA
1970 1:

EMR Air Photo
A 564-219

Weather data used for Sandy Lake is that determined at the Big Trout Lake weather monitoring facility, approximately 250 kilometres to the northeast:

Mean Temperature	High	Low
January	-19.4°C	-29.5°C
July	20.9°C	11.0°C
Annual Average Temperature	- 3.0°C	
January 2 1/2 % Design Temperature	-37.8°C	
Degree-Days	7800°C	
Annual Precipitation		
Rainfall	30.1 cm	
Snowfall	21.4 cm	
Average Annual Wind Speed	14.8 km/h	

Heavy equipment available in the community is either band or MTC owned. The band has a Link-Belt shovel and two small John Deere front end loaders, with back hoe attachment. The MTC has four dumptrucks, 2 graders, 1 Case bulldozer, 1 D-850 John Deere Bulldozer, a 1.9 m^3 front end loader and a gravel packer.

MTC equipment can be rented. A bulldozer costs $63/hour. A dumptruck costs $38/hour. A grader costs $42/hour and a 1.5 m^3 front-end loader costs $50/hour. In addition, the labour costs are $15.55/hour and $14.23/hour for the operator and his assistant. Overtime rates are $19.60/hour and $17.93/hour respectively.

The major fuels used in the community are wood, fuel oil, gasoline and propane. Propane is limited largely to cooking purposes (21,820 litres - 1981). Gasoline is available for vehicular use from the Hudson Bay at 88¢/L (1981). In 1981, approximately 360,000 L was used.

Wood is the fuel almost universally used for space heating in native households. A figure of 9.1 oven dry megagrams (ODMg) (10 cords) of wood per household per year, as indicated in other recent reports seems reasonable. Total community requirements would be approximately 2180 ODMg (2400 cords).

Fuel oil is used mainly for government institutional heating and operation of mobile equipment and diesel generation. Total quantities shipped in 1981 were approximately 1,000,000 L, at 41-67¢/L. It is supplied via Red Lake and Winnipeg.

3.2 Electricity Supply

Facilities

Electricity in Sandy Lake is supplied from a central generating station operated by Ontario Hydro. The facility contains three generating units, two 175 kW machines and one 440 kW machine. It is located next to the MTC facilities at the airport (Figure 5).

Unit 1 is a 175 kW, 218.7 kVA 1800 rpm machine connected to a six cylinder, turbo-charged Allis Chalmers engine, equipped with a hydraulic governor. This unit is the oldest and is incapable of meeting community peak loads, unless paralleled with other units.

Unit 2 is a 175 kW, 218.7 kVA 1800 RPM machine equipped with a six cylinder, turbo-charged in-line Caterpillar 3406 engine and Newage Stamford Generator. This unit is equipped with a Barber-Coleman DYN1 Electronic Governor. This unit is used in parallel with Units 1 or 3 to meet system peaks. The equipment was supplied by Mechron Engineering and Powell Equipment.

Unit 3 is a 440 kW, 412 kVA, 1800 RPM machine equipped with a V12, dual turbo-charged Caterpillar 3412 engine and a Newage Stamford 456.25 kVA rated generator. The unit is equipped with a Woodward Electronic Governor, for parallel operation. It is capable of meeting the community peaks in the coming year.

Fuel

There is on-site storage for approximately 65,800 L of fuel in a 2.54 m diameter by 7.62 m long tank to the west of the building. Fuel is delivered directly from supply planes by unloading hoses. Elsewhere in the community, fuel is transported from the airport by truck mounted tanks holding 1362 L. A tractor delivers 2 tanks per trip.

Fuel is delivered to the storage tanks of the Ontario Hydro installation at an estimated average 1983 cost of 61¢/L. Of this, 28¢ is the base price, 31¢ is for delivery and 2¢/L covers miscellaneous expenses. The 1982 and 1981 costs were 54¢/L and 44¢/L respectively.

The 1982 total diesel fuel consumption was 606,871 L, up from 589,427 L in 1981. The corresponding total fuel costs were $326,246 and $261,157. Unit efficiency was 2.83 kWh/L or approximately 26 percent.

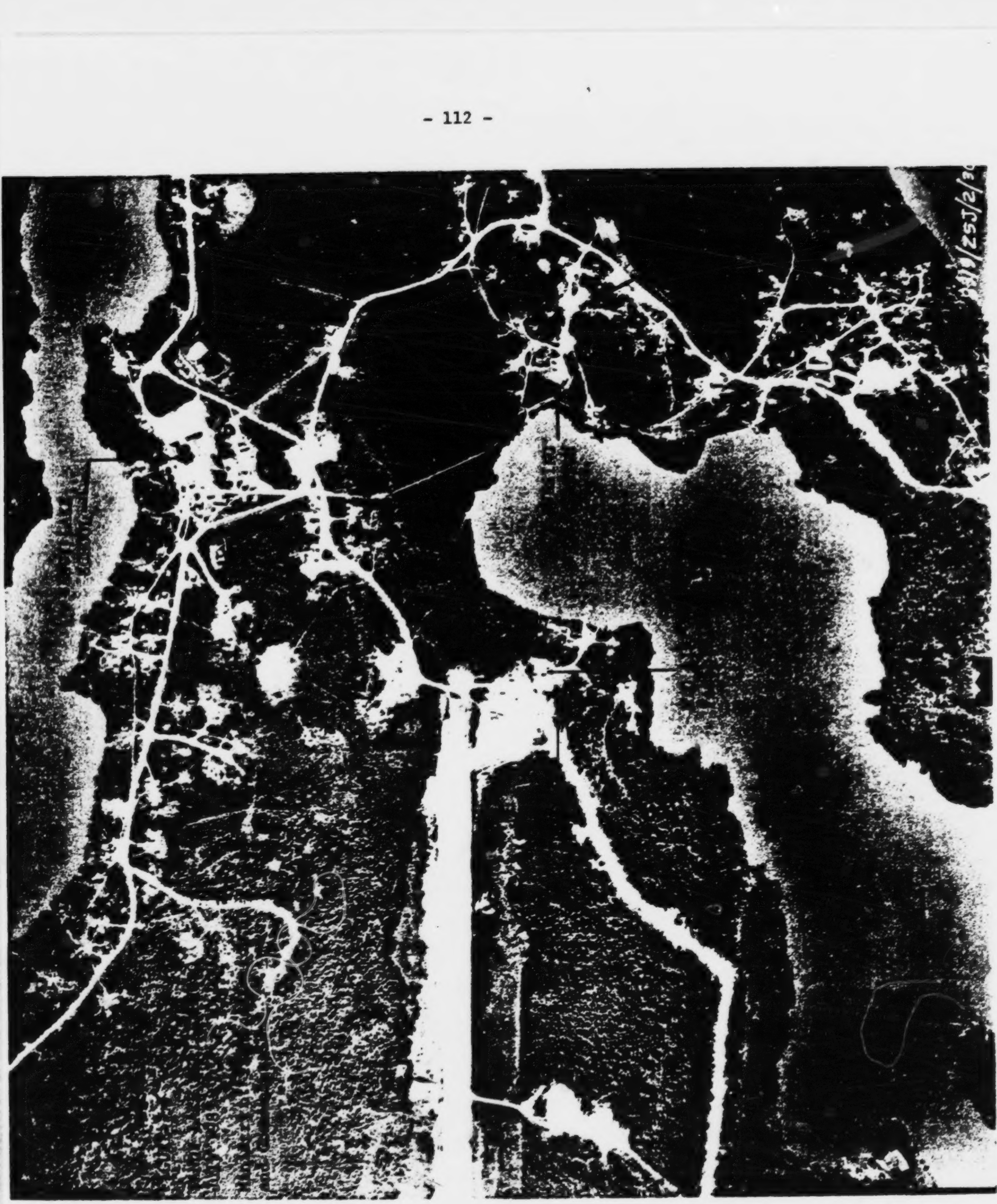
Production

Total production by the Ontario Hydro units in Sandy Lake in 1982 was 1,715,200 kWh, up from 1,467,500 kWh in 1981. The peak in 1982 was approximately 430 kW at the end of December 1982/January 1983. The peak for 1981 was 360 kW in December 1981/January 1982 (Figure 6).

The average load to average peak load for 1982 was 195.8 kW/326.5 kW or 0.60. This was down from 167.5 kW/265.4 kW or 0.63 in 1981. This is not unexpected since the peak load is likely to grow at least as fast and normally faster than the average load. The night load level is not expected to grow significantly and this affects average load figures, but not peak load figures.

Costs

The total cost of production and distribution in Sandy Lake in 1982 was $539,408. In 1981, the total cost was $468,584.


25J/2/3

Diesel Heat Availability

At full load, the 440 kW unit can produce 385 kW or 1.39 GJ/h of coolant heat. The smaller units at 175 kW full load produce about 120 kW or 0.43 GJ/h of coolant heat. A rough estimate of the annual diesel heat available is 4800 GJ or 124,440 L of fuel oil equivalent.

Near Term Future Plans

Ontario Hydro has preliminary plans to install two new units in Sandy Lake. The first, a new 600 kW machine, is planned for 1984/85 to replace one of the 175 kW machines. The second 175 kW is planned for replacement with a 260 kW unit in 1985/86.

The installation of these units will result in three graduated units, a 260 kW, a 440 kW and a 600 kW. This is being done in order to improve overall efficiency at the various load levels experienced in these communities. A remote radiator system and a secondary heat recovery system are planned for retrofit in order to improve operating efficiency, provide for easier unit cold start ups and to provide flexibility in the supply of diesel heat.

The current plans for new units and a general desire to maintain a centralized production facility do not favour the installation of decentralized units operating in conjunction with the central units.

Other Generation

Other than some small individual generators which may exist in some locations remote from those areas of the community serviced by Ontario Hydro, the only other generator in the community appears to be a 13.2 kW single phase emergency stand-by unit at the Nursing Station.

3.3 Alternative Generation Opportunities

The scope of this study is largely limited to wood based generation alternatives. Wind, hydraulic and photo-voltaic systems were outside of its scope.

One hydraulic application was briefly reviewed, which might be able to supply some hydraulic power from a facility being investigated for a mine development program.

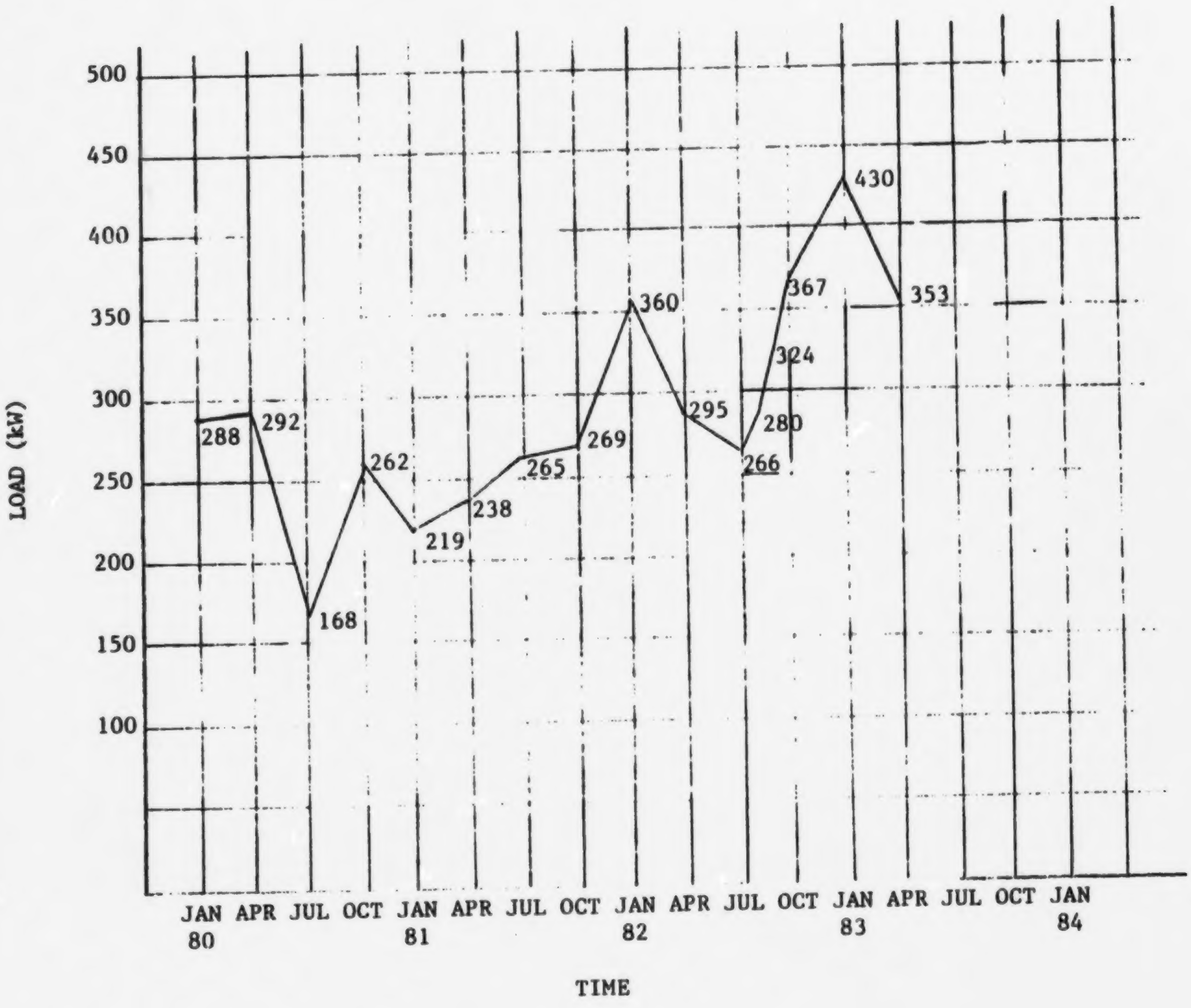
Hydraulic Power from Getty Mines, Berens River Gold Mine

The gold mine is being investigated for development potential by Getty Mines of California out of their Toronto office. The company had expected to make some decision on the project by the end of September 1983, but delays have reduced the priority of that decision. A decision is now expected no earlier than December 1983[C-28, C-35].

It should be noted that Getty Mines, based on their consultants' efforts, have decided that the rehabilitation of an existing hydraulic generation dam site, 12 km from the mine would be feasible. They feel that two 560 kW turbine generators could be justified at a cost of $4,000,000+.

FIGURE 6

SANDY LAKE PEAK LOADS
(1 - 440 kW, 2 - 175 kW Units)



Single Unit Peak - 440 kW
Parallel Unit
Operation Peak - 615 kW

They anticipate that there is considerable time when due to low water flows peak generation could not be attained and that for 1 month in a ten year period even one unit could not be run at full load.

It is expected that no more than probably 225 kW would be available for non-mine site uses. There are times when much less would be available. Indeed, the mine will itself operate diesels during its peak load periods to supplement the hydraulic plant.

The mine site and the hydraulic dam site are about 30 km south of Sandy Lake (Figure 7). A power line with the necessary transformation and protection equipment would be required. The long distance could have some adverse effects on the operation of diesels in parallel with this generation.

A brief economic analysis of this alternative showed that an investment in the neighbourhood of five million dollars would be required for transmission systems and roads. An additional cost, some proportion of the mine company's generating equipment investment, would also likely be incurred. A figure of $350,000 would be reasonable.

Line and generation maintenance costs would amount to about $100,000/year against a fuel savings of no more than $400,000. Thus, using simple payback analysis, ignoring escalation, a payback period of 20 years would be required. This would be totally unacceptable for the private portion of the funding, and for Ontario Hydro.

On a present worth basis, assuming oil escalates at 2 percent more than inflation and labour 1 percent less, the break-even point would be 18 years.

Given the difficulties and expenses involved and in view of the fact that there is no guarantee that supply from the mine site could be guaranteed ten years, let alone 20 years, this alternative was dropped from further consideration.

Wood Resource Base

Wood resource data for the area surrounding Sandy Lake is somewhat limited. This community had not had a great deal of work in this area.

In 1972, Program Management Evaluators (PME) and Terra Scann Limited conducted evaluations of forestry operations and of local topography[21, 22] for the band. The forestry evaluation (PME) provided the only indication of forest resources. Of the 4266 hectares of reserve land, 3924 hectares were considered forested and of this 70 percent was softwood, and 30 percent mixed wood. This was based on an estimate provided by the Sioux Lookout District office of the Ontario Ministry of Natural Resources based on an average 5 square kilometres of area for terrain typical of Sandy Lake. It contained 50 percent productive forest, 20 percent non-productive forest and 30 percent water. Of the productive forest, 60 percent was assumed spruce, 15 percent Jack Pine and 15-20 percent white birch and black poplar. The remainder is birch and fir.

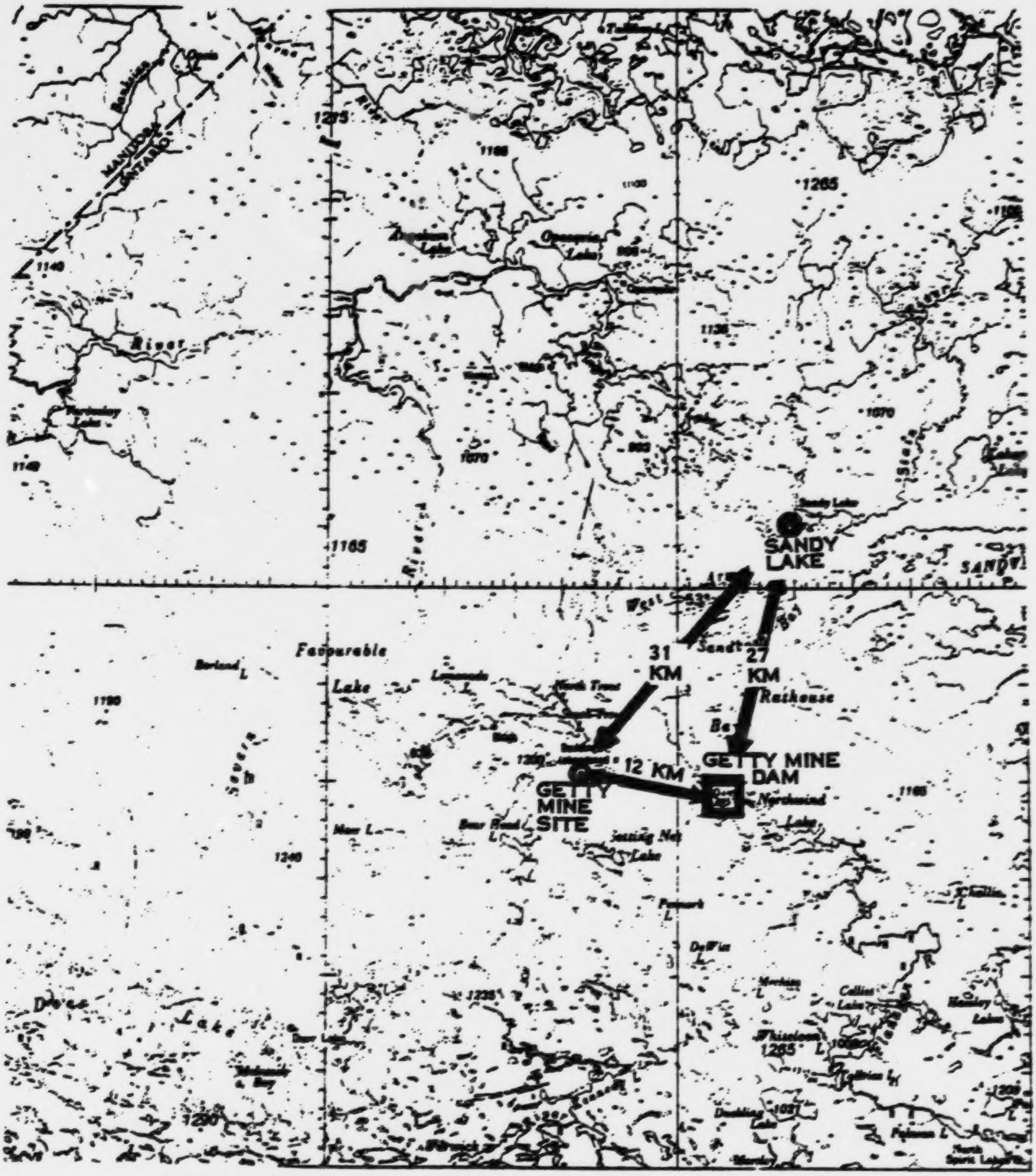


FIGURE 7

SANDY LAKE
GETTY MINES PROPOSED
MINE & POWER PLANT SITE

The results given for the ages and sizes at maturity,

Spruce	130 years	-	16.7 - 18.3 m
Jack Pine	100 years	-	16.7 m
Aspen	80 years	-	16.7 m

were confusing. This indicates Spruce is Class 1, Jack Pine Class 3 and Aspen Class 4. No explanation is given.

The end result of the analysis was that the average net merchantable oven dry megagrams per productive hectare was 29 (13 cords/acre). The mean annual increment in cubic metres per hectare was assumed less than 1.05 m^3/ha (softwood) (0.18 cords/acre).

This somewhat confusing data was the only data available to us specific to this area. As it was a rough estimate at best, a brief photo interpretation of the regions wood supply was done, plus some crude on-site data gathering to refine the photo interpretation results.

During a site visit in September to the community, two brief very crude forest cruisings were undertaken to provide background data. One was located just west of the airport facilities off the road to Finger Lake. The second was in a forested zone on the SE corner of the area containing the community (Figure 8).

Age and tree size data and some indication of spacings were recorded. In both cases, data gathering was limited to about 0.15 to 0.3 km in distance. Persistent rainfall hampered the activity.

The Ministry of National Resources Timber Sales Branch provided assistance by undertaking the basic air photo interpretation of areas around the community. Unfortunately at that time 1968 photo's at the 1:10,000 scale were the best available from DIAND. Allowance was made for this by updating the growth data using normal yield tables for the site classes arrived at. Areas in or near the community were excluded. Photographs taken in 1983 were used as they became available to modify the results.

It should be kept in mind that the study results are preliminary and provide only a basis for making decisions about wood use. They could not be used for a forest management program. Also no allowance is made for certain parts of the biomass, i.e. in branches and twigs. Depending on the method of harvest these sources may or may not contribute to the fuel feed stock quantities available.

The air photo interpretation covered a number of areas, some within the reserve and some outside. Although establishing some rough numbers for specific areas, the main goal was to estimate average wood quantities per hectare and wood growth.

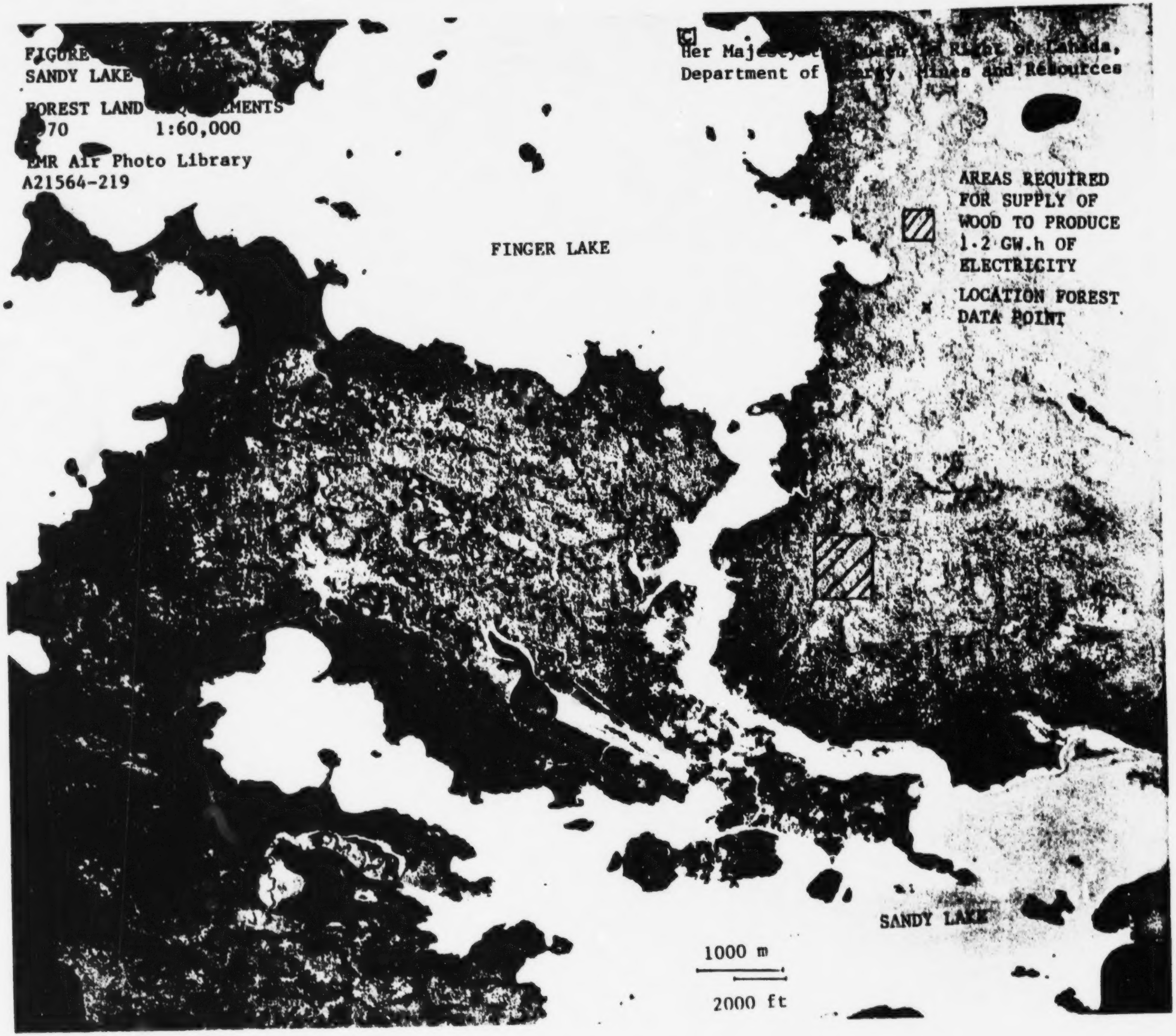


FIGURE
SANDY LAKE

FOREST LAND REQ EMENTS
 70 1:60,000

EMR Air Photo Library
A21564-219

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Department of rgy, Mines and Resources

FINGER LAKE
▨ AREAS REQUIRED FOR SUPPLY OF WOOD TO PRODUCE 1.2 GW.h OF ELECTRICITY
× LOCATION FOREST DATA POINT
SANDY LAKE
1000 m
2000 ft

The total forested area reviewed was about 7820 ha. The total volume standing based on the air photo interpretation adjusted to 1983 conditions was 833,000 m^3 (346,000 cords), or about 106 m^3/ha (17.82 cords/acre).

The actual values for different areas varied significantly from one area to the next. Values for the forested areas ranged from less than 20 ODMg/ha (8.9 cords/acre) to greater than 167 ODMg/ha (74 cords/acre). These do not take into account those areas of rock outcroppings or wetlands.

For the purpose of determining an annual allowable cut, the calculations were done for all of the areas examined and then brought to an average value per forested hectare. The resulting figure for a first year's operation showed 1.37 ODMg/ha/a (0.61 cords/acre/year) was allowed for an 85 year rotation and 20 year adjustment period. Eventually as normal growth was achieved, the annual allowable cut would fall to 0.82 ODMg/ha/a (0.37 cords/acre/year).

In terms of relating this to electricity generating potential, it is useful to think of the forested land area requirements for a given level of generation. For the purposes of this study, a 200 kW machine was assumed able to produce 70 percent of the Sandy Lake electricity requirements in 1983, or about 1,200,000 kWh. At 10 percent efficiency about 2100 ODMg (2300 cords) of wood would be required. To supply this would require a forested land "bank" of 1533 hectares at 1.37 ODMg/ha annual allowable cut and 2560 hectares at 0.82 ODMg/ha annual allowable cut. This is in excess of that normally required for community heating uses.

In terms of existing treed stock, to supply 2100 ODMg/a (2300 cords/year) one would have to cut down between 19 and 130 hectares of trees per year depending on the local volumes available. Figure 8 illustrates roughly these areas required in two specific locations.

Our estimates are somewhat higher than the earlier MNR 1972 data for both the wood available per hectare and the mean annual increment.

It is expected that approximately 75 percent of the reserve area of 4266 hectares less approximately 445 hectares in the community itself could be forested. Thus 2870 hectares on the reserve itself could be considered, plus extensive areas outside.

There appears to be adequate wood supply. The primary cutting areas initially would appear to be along the road going west from the airport and around the west end by the lake. Some road building to get to some areas may be necessary, but generally the main road provides good initial access and should permit almost year round activity. In view of the quantities required, year round access is an important factor.

The existing diesel facility is sited in an excellent location for wood use. The road from the airport passes right by and leads through the best forest land in the area. It is also in a good location to receive wood from the south shores west of the lake. In view of the by-product heat energy available from the electricity generation process, it may be advantageous for the band to consider locating any future facilities requiring heat, if economical, at this site.

3.4 Community Heat Users

In terms of facilities in the community which could use diesel heat from either a diesel facility or a wood based system for space or water heating, the choices are relatively limited. As in other communities they are the MTC Airport facilities, the school, the Nursing Station and the Hudson's Bay store. Alternatively, future facilities could be sited so as to take advantage of the waste heat available. A brief description of each outlining the heating requirements and limitations follows.

3.4.1 MTC Airport Facilities

The closest facility to the existing diesel generating station, the MTC facilities consist of a bunkhouse, a maintenance garage, and an unheated warehouse garage. Figures 5 and 9 locate and illustrate the layout of these facilities and the location of their heating facilities.

The maintenance garage has two small forced air furnaces, each a 172,000 kJ/h unit. Only one is used according to local MTC representatives. The other is a back-up. The bunkhouse has a single 123,00 kJ/h unit. The temperatures in the bunkhouse and maintenance garage are set at a lower temperature when not in use.

Fuel consumption data for the MTC facilities are not readily available. For the purposes of this study, consumption figures had to be determined, based on degree-day data and furnace size data. Since there is not full time occupation, an estimate of the appropriate degree-days information was necessary. A value of 5600°C degree-days was determined for the garage and 6638°C for the bunkhouse. Based on this method, it is estimated that 22,000 L/a of fuel oil is required at a cost of $13,400/a (1983). This is in relatively good agreement with an earlier Hedlin estimate of 20,462 L.

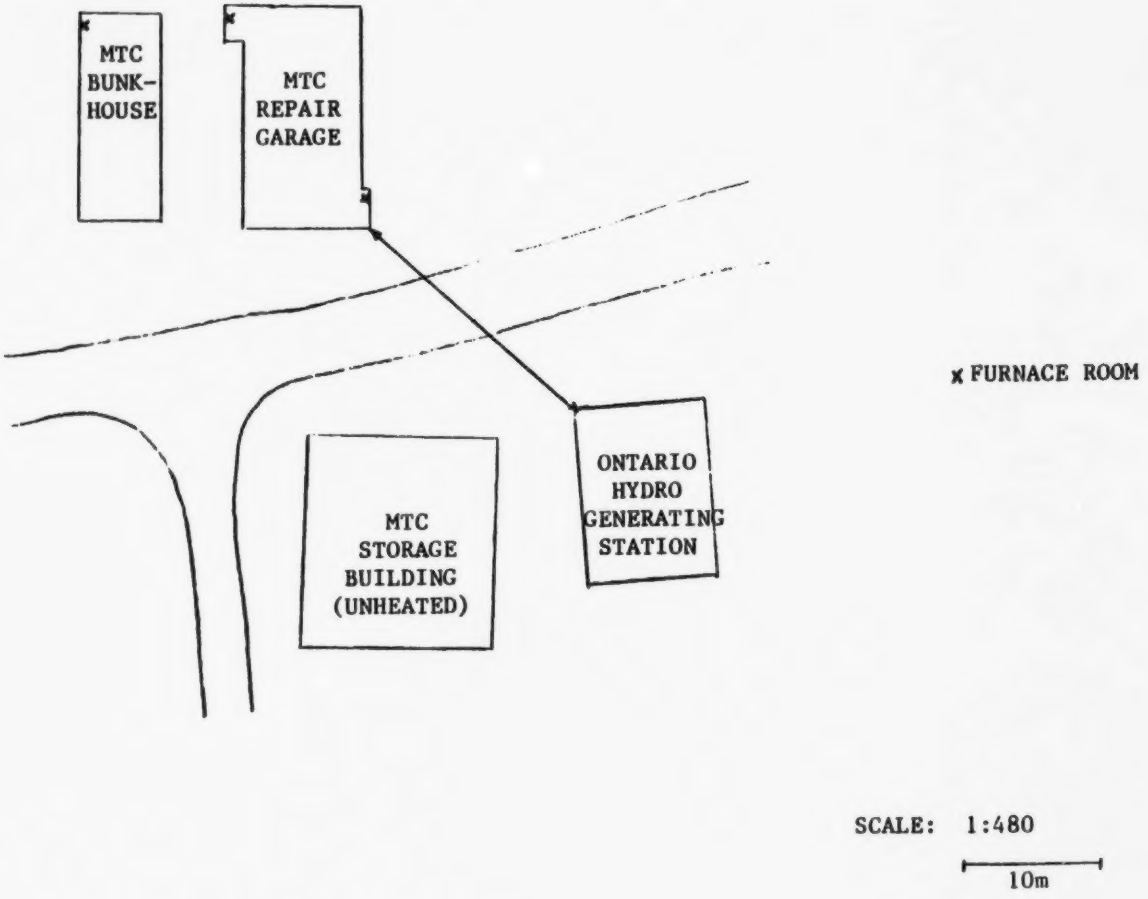
3.4.2 Sandy Lake School

The Sandy Lake School consists of several main buildings and numerous teacherages, as well as other ancillary buildings. Space and hot water heating in the main building is provided by oil fuelled equipment.

Figure 5, an aerial photograph, shows the location of the school and the layout of the buildings. Figure 10 is a sketch of these same facilities locating the major heating facilities.

FIGURE 9

SANDY LAKE
MTC FACILITIES


MTC BUNK-HOUSE
MTC REPAIR GARAGE
ONTARIO HYDRO GENERATING STATION
MTC STORAGE BUILDING (UNHEATED)
x FURNACE ROOM
SCALE: 1:480
10m

The 1982/83 fuel consumption at Sandy Lake School according to a DIAND source was 272,400 litres. This is a relatively good agreement with R. Hedlin values of 272,760 litres. Based on furnace and degree-day data, the normal fuel consumption would be expected to be about 255,000 litres for school building space heating and 150,000 litres for the teacherages. A rough estimate of individual building consumption based on their unit rating and normal degree-days is as follows:

• Main School Building	- Mechanical Room 1	55,000 L
	- Mechanical Room 2	
	- Furnaces	55,000 L
	- Hot Water	12,000 L
	- Mechanical Room 3	66,000 L
• Two Room School Building		22,000 L
• Three Room School Building		22,000 L
• Workshop/Home Ec Building		22,000 L
• Teacherages (15)		150,000 L

The value of the fuel used depends on the estimate of the annual fuel requirement one accepts. At $0.63/L (1983) the value could vary between $255,000 (405,000 L) and $172,000 (272,400 L).

There is insufficient space to provide for a wood based system in the vicinity of the school. Fuel delivery and storage requirements alone would interfere greatly with the normal routine of the community and adversely affect the orderly operation of the school. Economics aside, such a system would not be desirable.

There is sufficient space in the vicinity of the school for a diesel unit(s) in order to provide diesel heat use. The most logical site if such a unit were contemplated would be near the main gymnasium entrance. The mechanical room includes two furnaces and hot water heating for the gymnasium showers and is located on an exterior wall. The other mechanical rooms contain less equipment and/or are less accessible. The Regional Ontario Hydro authorities responsible for operating the community electricity production and distribution system would likely oppose such a system, as a complication of their operation. Such an installation would then have to operate on a stand alone basis.

3.4.3 Nursing Station

The nursing station is located as illustrated in the aerial photograph. It is heated by four 130,000 kJ/h (net) furnaces and hot water is provided by an oil fuelled heater consuming 6.62 L/h. According to Health and Welfare Department sources, 34,430 litres of fuel oil was delivered in the 1982/83 heating season to the station for space heating and hot water heating. R. Hedlin Associates arrived at a figure of 60,130 L for the Sandy Lake Nursing station in 1981. This figure is in relative agreement with the normal expected fuel consumption based on the furnace and hot water unit sizes and the degree-day data, 55,000 L. The value of the 55,000 L of fuel at 63¢/L would be $34,700 (1983).

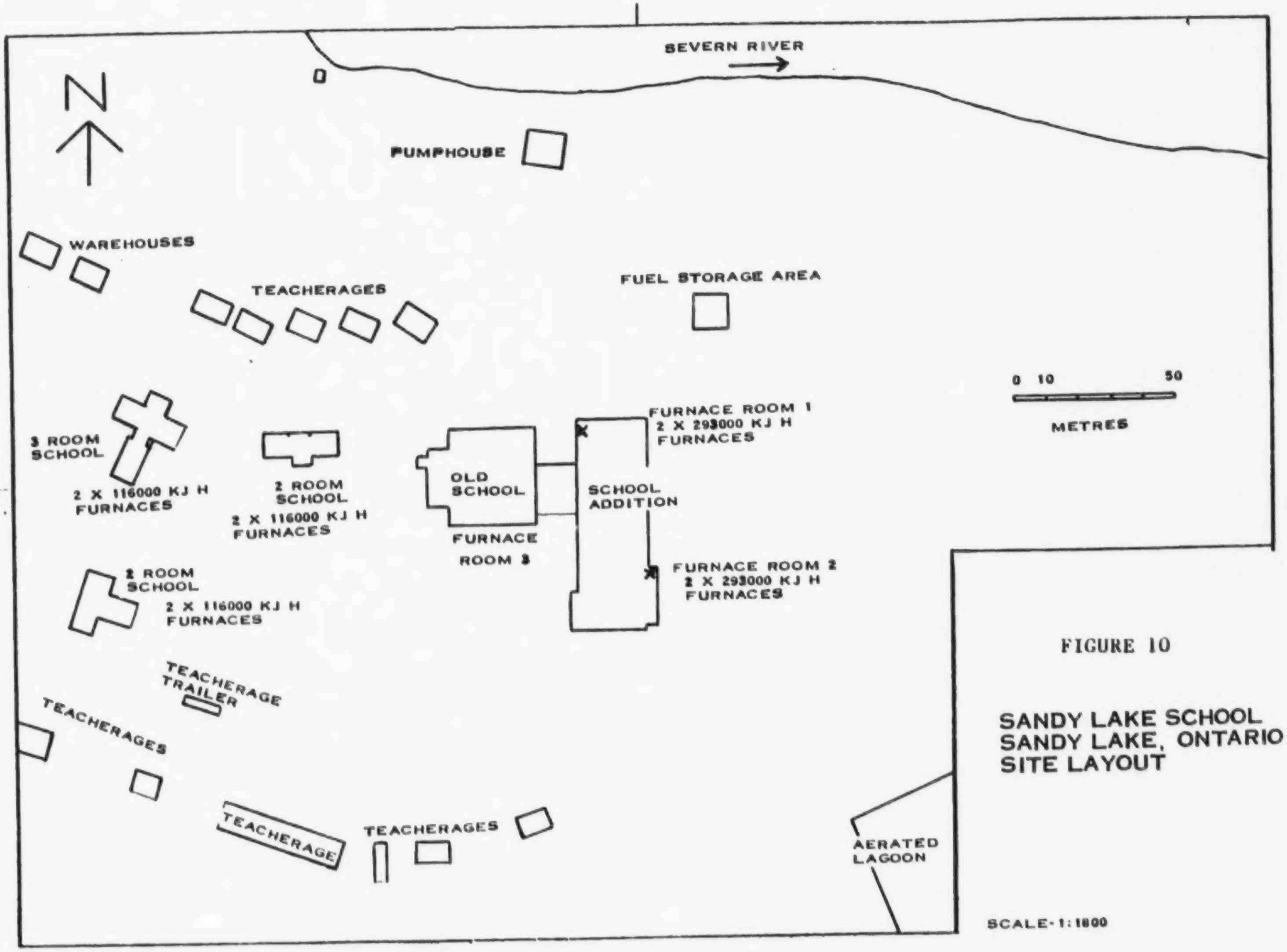


FIGURE 10

SANDY LAKE SCHOOL
SANDY LAKE, ONTARIO
SITE LAYOUT

The nursing station is not favourably located to the existing generators, and the topography and development in the general area does not favour relocation of a unit, over that for the school. Further, a relocation would involve rewiring some of the system to be able to supply the power to the system from what is now a one phase zone. In addition, the distance for providing communications between generating units would be even further.

3.4.4 Hudson's Bay

The Bay is located fairly remote from the community. Based on the 169,000 kJ/h store furnace size and an assumed 127,000 kJ/h manager's residence furnace heating system capacity and degree-day data, it is expected that approximately 28,500 L of heating fuel is consumed, at a total cost of $17,700 (1983). The remoteness of the facility, the low heating fuel quantity and value and the advantages of other sites make this an unlikely candidate for waste heat use.

3.4.5 Potential Applications

In order to utilize most cost-effectively the energy from the by-product heat produced by the diesel or wood based generation systems, other potential applications were sought.

A vegetable greenhouse was considered, but in all remote sites, it was clear in interviews with local store operators and Hudson Bay managers that no sizable market exists. Generally, no more than $50-100/week was spent on these foods.

Three other major potential users for by-product heat would be a community centre, a laundromat or a community motel. At the present time, there are no definite band plans for a laundromat or community centre or motel. If such items were developed, it would be highly recommended that said facilities be located near the existing diesel plant in order to have an easy access to a hot water supply.

It is estimated that the heat requirement would be approximately 87,000,000 kJ/a (2300 L oil equivalent) for the laundromat, 1.18×10^9 kJ/a (31,000 L oil equivalent) for a small community motel or a small community centre, depending largely on the specifics involved. The values of this energy in oil equivalent are approximately $1,500 and $20,000/a (1983) respectively. In the case of the laundromat, by-product heat could also supply building heating of 8100 L or $5,200/a approximately.

3.5 Community Response to Electricity Generation and Diesel Heat Applications

Sandy Lake is a progressive Indian community, looking for means to improve their overall employment situation. The band, under Chief Fiddler, are interested in means of expanding the quantity of electricity available. In 1981, electrification amounted to 65 percent of community households. This has expanded, and is expected to continue. This is reflected in the load growth in Figure 4.

The band is interested in wood and hydraulic energy systems. It appears that the hydraulic option is not economically feasible in view of the potential reliability and delivered quantities.

They are on the other hand concerned about the quantities of wood likely to be consumed in a large wood generation scheme of as much as 300 kW. They initially did not realize the quantities involved. A smaller base-loaded 100 kW system might be more to their satisfaction, minimizing the effect on the environment, while maximizing the job opportunities.

In terms of using diesel by-product heat at the school, the chief expressed some concern over the noise, but had no objections if the noise were reduced to an acceptable level. They would like to see such a unit be able to supply the school in isolation if the electricity supply system fails.

In as far as future development plans are concerned, the band is now reviewing a community plan report[17]. No specific features were available for publication at this time.

There was no particular concern by the band expressed over the use of diesel heat. It does seem particularly concerned over equal distribution of benefits. Thus, it would be unlikely that one could supply diesel heat to only some community members. They had no particular comments on supplying institutional facilities.

4.0 BIG TROUT LAKE

4.1 Community Background Data

Big Trout Lake is a native community of approximately 750 persons, 700 native and 50 non-native in 135 households. It is located approximately 220 km north of Pickle Lake and 440 km northeast of Sioux Lookout at 53°N49'Latitude, 80°W53'Longitude (Figure 11).

Big Trout Lake is the centre of the Kayhanna Tribal Council. The other band communities include Angling Lake, Port Severn, Kasibonika Lake, Wunnommin Lake, Kingfisher Lake, and Long Dog Lake. The primary languages in the Kayhanna Tribal Council area are Ojibway, Cree and English. The Tribal Council and Big Trout Lake Band Chief is Gerald McKay.

Big Trout is currently accessible on a regular basis only by air. A winter road is also used, but on an irregular basis. It is not regularly maintained. Bearskin Lake Airways, Big Trout Airlines and Austin Airways all operate commercial flights out of Big Trout Lake. Bearskin and Big Trout operate a seaplane base, while Austin and Bearskin use the MTC airstrip. The airstrip is a 1067 m gravel runway. Access is limited to this length due to physical obstructions at the ends. A Hercules aircraft could not be used to supply heavier equipment. The airport is equipped with landing lights, and a non-directional beacon.

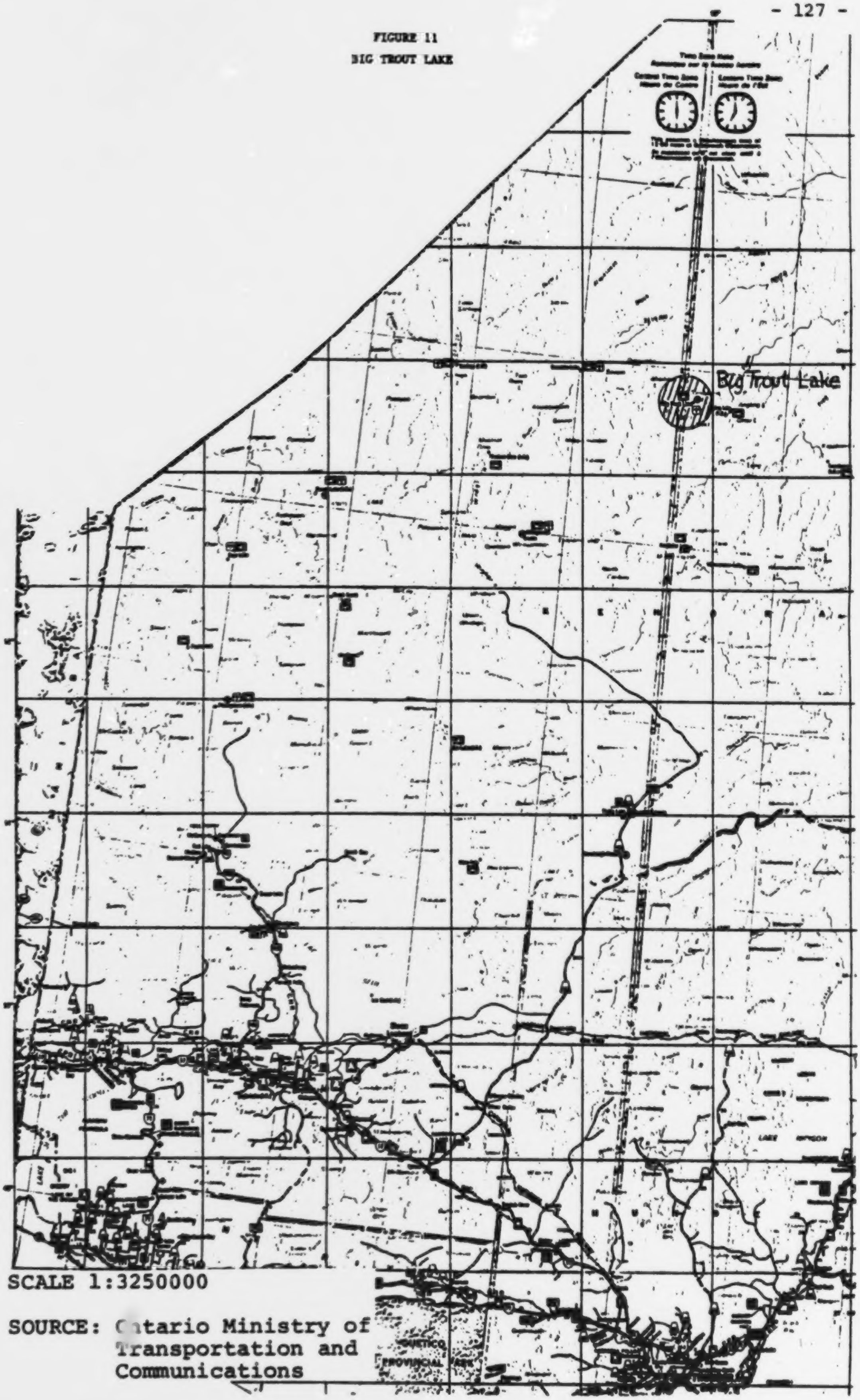
Numerous studies and projects have been undertaken for the Big Trout Lake community, including this study, a previous energy use study by Middleton and Associates, the R. Hedlin Data Base Study, a community planning study and an arena feasibility study by Marshall, Macklin, Monaghan.

Many of the major facilities in Big Trout Lake are government owned or supported, including:

- School - one two room
  - one portable
  - one six room
  - five teacherages
- MTC airport facility, bunkhouse, garage
- Ontario Hydro Diesel Generator Installation
- Big Trout Lake Weather Station
- Nursing Station

FIGURE 11

BIG TROUT LAKE



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SOURCE: Ontario Ministry of
Transportation and
Communications

Also in Big Trout, there are several other private or band operated facilities,

- A Co-op store
- A freezer plant
- A radio station
- several churches
- a furniture "factory"
- coffee shop
- band office
- community hall/coffee shop
- Hudson's Bay Company
- Trout Lake Air

Weather data for the community is from the on-site government installation. The basic parameters are:

Mean Temperature	High	Low
January	-19.4°C	-29.5°C
July	20.9°C	11.0°C
Annual Average Temperature	- 3.0°C	
January 2 1/2 % Design Temperature	-37.8°C	
Degree-Days	7800°C	
Annual Precipitation		
Rainfall	30.1 cm	
Snowfall	21.4 cm	
Average Annual Wind Speed	14.8 km/h	

Relative to many other communities, Big Trout Lake has considerable economic activity, including:

- Band and Tribal Council and Administration
- Primary School
- Construction
- Heavy Equipment Operation
- Health Centre
- Seasonal Trapping
- Trout Lake Air
- MTC Airport
- Bell Canada Remote Site Staff Residence
- Hudson Bay Store
- Co-operative Store
- Freezer Plant
- Furniture Shop
- Community Coffee Shop
- Bearskin Air
- Ontario Hydro Diesels
- Weather Station
- Band Craft Store

Chief McKay and the council are actively improving the services available to the community. Following the completion in 1982 of a community planning study, the band is now having a number of recommended projects implemented, including:

(a) The provision of drinking water wells at strategic points throughout the community, as well as piped systems to major facilities such as the school.

(b) The provision of a sewage collection system from individual holding tanks and central piped sewage from major facilities.

(c) The improvement of roadbeds.

(d) The provision of a new band garage and fire truck.

(e) General improvements to community facilities.

More heavy equipment exists in Big Trout than in most remote communities. The band currently owns and operates several pieces of equipment and rents these to outside users, including:

- a bulldozer (needs repair) -
- two five ton dump trucks - $45/h
- two tractors - $25/h
- one back hoe - $65/h

The operator's wages and fuel cost are not included in these figures.

In addition, they will over the next year acquire two sewage trucks, another gravel dump truck and a fire truck. These will all be stored and maintained at the new band garage site near the causeway. This garage is currently under construction and should be completed by December 1983. The new equipment is being brought in on a new winter road to the community.

The Ministry of Transportation and Communication also has equipment at Big Trout Lake and is prepared to rent this out, including

- a grader - $42/h
- a bulldozer - $63/h
- two five ton dump trucks - $30/h
- a front end loader - $50/hr

In addition, the labour costs are $15.55/h for the operator and $14.23/h for his assistant. Overtime rates are $19.60/h and $17.93/h respectively. Arrangements would have to be made to avoid conflicts with equipment needs at the airport itself. Bearskin Air also owns and operates a back hoe.

The major fuels used in the community are wood, fuel oil, propane and naptha and gasoline.

Propane and naptha use is limited to cooking. According to the Middleton study, approximately 6800 kg of propane and 4500 litres of naptha were used in 1981.

Wood is used for household heating and heating the main school building. Each native home uses about 12-15 ODMg (13-16 cords) per year and the school about 90 ODMg (100 cords). In total, about 1900 ODMg (2100 cords) of wood are required for the community.

Fuel oils have many uses in the community. According to the Middleton study, about 164,000 litres was required for institutional and commercial heating; and 481,000 L for electricity generation in 1981. Gasoline for ski-doos, small gasoline generators and boats and light vehicles account for 80,000 litres and aircraft fuel 1,360,000 litres.

Fuel costs vary significantly in the community. Typical December 31, 1981 prices as determined by Middleton Associates were:

Propane	$2.65/kg
Naptha	$1.75/L
Gasoline	$0.86/L
Fuel Oil	$0.606-0.683/L
Aviation Fuel	$0.70-0.80/L

4.2 Electricity Supply

Facilities

Electricity in Big Trout Lake is supplied from central generating facilities on Post Island and by individual private gasoline generators on the mainland. Ontario Hydro operates the main central generating facility supplying most of Post Island. The Weather Station has diesels which supply their own compound and the band Office (Figure 12).

The Weather Station facilities consist of three 100 kW, turbo-charged, six cylinder, Deutz diesels with Bosch electronic governors and Brown-Boveri generators. These are new units and supply a peak load of about 20-30 kW. They replaced older 100 kW machines which had, at one time, supplied much more of the community, including the Bay store. It appears that units of the same size were ordered without consideration given to the reduced load. In order to improve unit maintenance, electric heating of the weather station buildings and resistor banks are being considered to increase the load. Fuel is delivered to the weather station in 4000 L tanks brought in from the airport by band tractor.

Ontario Hydro's generating facility is currently installed about halfway between the community and the airport on Post Island, about 180 m from the Bell Canada facility. The facility consists of three 125 kW units. Parallel operation is necessary to meet peak loads and is provided for in the design of the system.

All three units are 125 kW, 156.25 kVA 1800 rpm machines, equipped with six cylinder, turbo-charged Caterpillar B306 engines equipped with hydraulic governors. These units are some of the first installed by Ontario Hydro in remote sites.

Fuel

On-site fuel storage is provided by eight 4100 L storage tanks piped in parallel. Each is 1.2 m in diameter by 3.5 m long. Fuel is off loaded from the planes into 4100 L truck mounted tanks. It is then hauled to the generating site.

The 1982 total fuel consumption was 333,022 L at approximately 56¢/L or $185,144. This compares with 274,356 L at 50¢/L or $137,584 in 1981.

Production

Total Ontario Hydro electricity production in Big Trout Lake in 1982 was 784,250 kWh. The average efficiency was 2.35 kWh/L or approximately

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21.9 percent. In 1981, the total production was 743,200 kWh at an average efficiency of 2.71 kWh/L or 25.2 percent. No peak load data is available. Using the average load to peak load value for Sandy Lake, a peak of approximately 150 kW is expected. This appears reasonably valid.

Costs

The total cost of production and distribution in Big Trout Lake in 1982 was $314,983. In 1981, the total cost was $297,543.

Diesel Heat Availability

At full load, the 125 kW units produce approximately 115 kW or 414,000 kJ/h of coolant heat. A rough estimate of the annual diesel heat available is 2600 GJ or 67,000 L of fuel oil equivalent.

Future Generation

Ontario Hydro, DIAND and the Big Trout Lake band have an agreement to extend the electricity supply to the three mainland settlements in 1984.

New lines and distribution equipment will be installed and the new generators will also be installed to better serve the community. Efforts are being made to improve both the service and the efficiency of the Big Trout Lake operation. A new graduated unit size approach will be used. Three units at 175 kW, 260 kW and 400 kW will be installed. In addition, external radiators and a microcomputer control system will be incorporated as the new units are installed. The package will mean that units will be able to be run at their peak efficiency and that the auxiliary equipment will use the minimum amount of power.

The new equipment should also improve the start-up capability of the equipment, maintain a continuous record of production and reduce the time an operator is needed to turn units on or off. New installations at other sites are also expected to use this type of set-up. The savings are expected to more than cover the costs. It may have the additional benefit of having an auxiliary take-off for diesel heat use.

Other Generation

Middleton in their 1982 study, reported that the Band Council estimated that approximately 50 unserviced households had their own gasoline fuelled electric generators such as the Honda EG 1500 (1.5 kW). These generator units cost substantially more than subsidized power from Ontario Hydro. These units will be phased out as service is extended to households on the mainland.

4.3 Alternative Generation Opportunities

The scope of this study is limited largely to wood systems. Wind and photo-voltaic were not considered. Hydraulic generation potential around Big Trout Lake was rated as poor in the Middleton study[10]. No further evaluation was made.

Wood Resource Base

Wood resource data in the Big Trout Lake area is somewhat limited. At 53°49'N it is in that area above the 52nd parallel, where the Ontario Ministry of Natural Resources does not normally conduct forest inventory assessments.

Forestry assessments were undertaken in 1972 and 1982. In 1972, Program Management Evaluations conducted an evaluation of the forestry operations for the band[23]. In 1982, KBM Foresters conducted a review of forest resources for the Kayhanna bands reserves under a program with Middleton Associates.

The examination by PME indicated that of the 11,091 ha of reserve forested land, most was immature softwood. Eighteen percent was mature softwood, 63 percent immature softwood and 19 percent immature mixed wood. The on-reserve average net merchantable ODMg/ha was estimated at 22.4. The mean annual increment determined for the softwood was 1.05 m^3/ha.

Off reserve the PME study assumed a terrain consisting of 30 percent water, 50 percent productive forest and 20 percent non-productive. Of the productive forest, 60 percent was assumed spruce, 15 percent jackpine and 25 percent poplar or birch. These values were arrived at based on an average square kilometre within a 96 km radius of the reserve boundary.

The end result of the off-reserve analysis was that the average net merchantable oven dry megagrams per productive hectare was 29 (13 cords/acre). The mean annual increment in cubic metres per hectare was assumed 0.77 m^3/ha (0.13 cords/acre).

The 1982 KBM work was based on a preliminary air photo interpretation of 1:50,000 air photographs without on the ground site visits[C-12]. It was designed to provide a rough indication of the magnitude of annual wood cut permitted. Thus it provided some measure of guidance as to the feasibility of wood based electricity generation. It indicated that an annual wood surplus of approximately 6600 ODMg (7280 cords) was available.

In view of this previous work, it was decided to conduct a brief examination to verify the results of the KBM study. A site visit to Big Trout Lake was conducted including some crude forest cruising to determine some site data on ages, sizes and heights from which to perform a more accurate photo-interpretation. Sites of those cruises are located on Figure 13.

The Ministry of Natural Resources Timber Sales Branch provided assistance in roughly interpreting 1:10,000 scale aerial photos of Big Trout Lake made available through DIAND. The analysis was very rough, and intended only to provide the crude data necessary to verify earlier works.

The results of computations based on the site visits and rough aerial photograph interpretation verified the KBM findings. There is approximately 9000 ODMg (9900 cords) of renewable growth on the reserve.

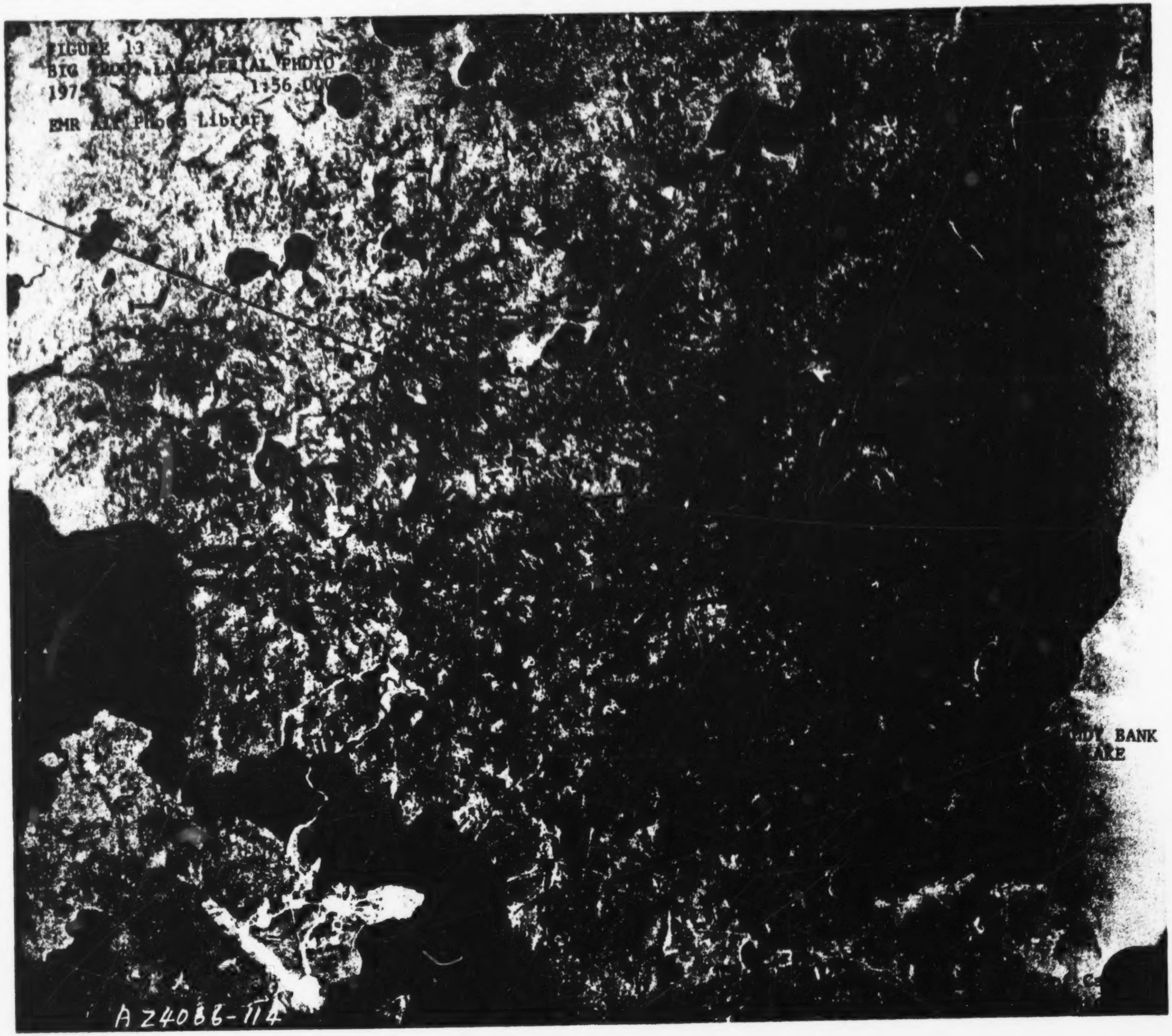


FIGURE 13
BIG TROUT LAKE AERIAL PHOTO
1975 1:56,000

EMR Air Photo Library

It should be noted however that since the best growth areas are to be excluded from consideration at the band's request, much of the remaining areas are very poor. Most of the trees in these areas are low quality and very old. The economics of collection and regrowth potential are highly suspect. Many of the areas are fairly wet. Harvesting whole areas could lead to an increase in ground moisture in the area, creating more swampy conditions. Regrowth could also be a problem. It is unlikely that replanting could be justified, and it is very uncertain as to when or how the areas would regenerate.

Wood based generation is not a feasible alternative for the community of Big Trout Lake. The quality and quantity of wood and the potential effects on the environment, native wildlife and the band itself make its use for electricity generation inadvisable given the band's request to have the good stands for individual use.

4.4 Community Heat Users

The major institutional or commercial facilities which might use by-product heat from a diesel or wood based system for space and water heating are relatively few. As in most other northern communities, there is the Bay store, the school, the nursing station, the airport, the band office and local churches. In addition, Bell Canada operates a regional maintenance staff residence, and there is a Federal Government Weather Station. The band or its members also operate a Co-op store and a recreation centre/snack bar and are currently building a maintenance garage.

4.4.1 MTC Airport Facilities

The MTC airport facilities in Big Trout Lake consist of a small bunkhouse/office, a maintenance garage and a small waiting room building. Unlike the other two native communities in this study, the MTC airport facilities are not the closest installation to the existing diesels.

The maintenance garage has two small forced air furnaces, each a 170,000 kJ/hour unit, only one of which is reported to be operated at a time. The bunkhouse has a single 123,000 kJ/hour unit. The unit in these facilities are set to operate when occupied to maintain a 15-21°C temperature and when unoccupied, 10°C or less. Staff are expected to be on site eight hours a day, five days a week in summer and fall and seven days a week during winter. The maintenance garage is utilized infrequently.

Fuel consumption data, as mentioned previously, is unavailable from the MTC for its facilities. Estimates were obtained using the degree-day and furnace capacity approach. As for Sandy Lake it was estimated that the appropriate value of degree-days is 5600°C for the garage and 6638°C for the bunkhouse. Based on this and the furnace data, the fuel oil consumption and costs are 11900 L/a and $ 7,380/a for the garage and 10,100 L/a and $6,260/a for the bunkhouse.

4.4.2 Big Trout Lake School

The Big Trout Lake School consists of two main school buildings, one large portable and several teacherages. The main school building is a six room school. A new two room building was completed in 1982.

The main school building is about fifteen years old and contains about 840 m^2 of floor space. It is heated by wood supplied under contract by the band. Figure 12 shows its approximate location and the layout of the school buildings. This building is heated by hot water supplied by two hot water boilers located in a separate building just to the east of the main school building.

The boilers can operate in parallel, although only one at a time is usually used. Each supplies 2353 kPa water at 55°C. The water is returned to the system via recirculation piping (Figure 14). The boilers themselves contain 16.17 m^2 of heating surface. Based on the ratings of the Steel Boiler Institute, this is equivalent to roughly 428,600 kJ/h.

The 1982/83 fuel consumption of the main school building was 91 to 100 ODMg (100 to 110 cords) of wood according to the school principal and the band. Based on degree-day calculations, one would expect approximately 100 ODMg (110 cords) approximately. At $110-130/ODMg ($100-120/cord), the annum heating fuel cost is $10-12,000. In addition, the school has an oil fuelled hot water heater. No data is available, but is not expected to consume more than approximately 3635 L of fuel oil at a cost of $2,300/annum.

The new two room school building is solar heated, with oil/wood combination furnace back-up and supplement. This facility has only gone through one partial winter heating season. During this time, the solar system did not operate to its full potential, perhaps due to its late start-up. It may not have had the accumulative capability to minimize oil use. In the period, January to April about 5000 L of fuel oil was required. Assuming that this sort of pattern continued, the total fuel oil consumption for heating would be less than 10,000 L or $6,400/annum.

Each of the six teacherages is equipped with a 118,000 kJ/hr (net) oil furnace. The consumption expected is about 11,360 litres at a cost of 0.64¢/L or about $7,300(1983$).

The use of wood and solar energies in the school, makes the application of a wood combined heat and power facility, infeasible. In addition, it is unlikely that heat supply from the existing diesels could be considered. Even if it were economically feasible, it would mean the loss of jobs for those supplying wood to the school.

4.4.3 Department of Environment Weather Station

The Federal Department of the Environment operates a significant weather station in Big Trout Lake. Data is used for design purposes, in most communities in these areas. It is particularly important as a source of upper atmosphere data.

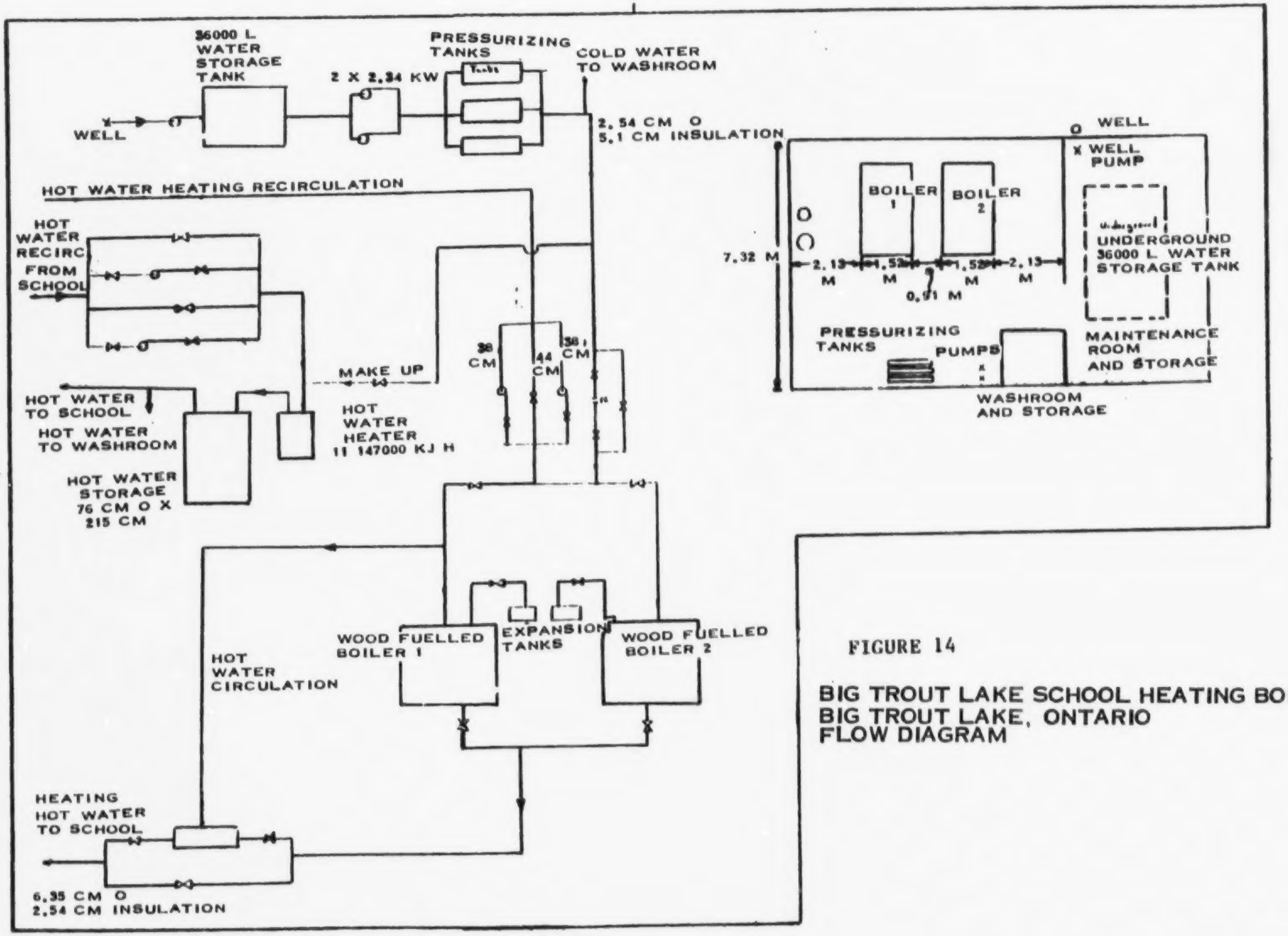


FIGURE 14

BIG TROUT LAKE SCHOOL HEATING BOILERS
BIG TROUT LAKE, ONTARIO
FLOW DIAGRAM

The weather station is at the easterly tip of Post Island and consists of numerous buildings and staff houses (Figure 12). The station has its own diesel generators and distribution system. In addition to its own electrical requirements, it also supplies the band office.

Heating is mostly by oil in each of these buildings, with consideration being given to some electrical heating. The station diesels currently operate at only 20-25 kW peak load, compared to their capacity of 100 kW (3 x 100 kW). This results in inefficient operation and is hard on the machines.

Cogeneration was apparently reviewed and dismissed by the Department according to the station staff. Certainly at 25 kW, the heat available would be minimal.

The station was considered for this study to be much too far from the existing Ontario Hydro station for consideration for heating with diesel heat. In so far as wood options, physical and logistical restraints would not permit the siting of a suitable unit nearby for by-product heat use, even if the wood resources were available. One item which might be considered at some point in time would be to partition the community so that the Environment Service generators supply more of the community and increase their load. This will improve their service life expectancy and may provide sufficient diesel heat for use in some of the buildings.

4.4.4 Hudson's Bay

As was the case for all remote communities, it was not considered feasible to consider the Bay as a potential heat energy customer. Although their heating oil consumption would be in the neighbourhood of 28,500 L/a or $18,300/a, they are sited too far from sources of by-product diesel heat and moving a facility could not be justified (Figure 12).

Even if wood use were feasible from a resource availability standpoint, logistical and physical obstacles would make heat supply to the Bay infeasible.

4.4.5 Nursing Station

The nursing station in Big Trout Lake is sited in the heart of the Reserve Community and is surrounded by community buildings (Figure 12).

The station is heated by four furnaces, supplying different areas of the station. They are rated at 158,000 kJ/h (net), 158,000 kJ/h (net), 195,000 kJ/h (net) and 116,000 kJ/h. In addition, there are two oil fuelled hot water heaters, each rated at 5.68 litres per hour of oil consumption at a heat recovery rate of 795 L/h each (T=55.5°C).

The oil delivered to the station in the period September 1, 1982 to August 31, 1983 was, according to a Health and Welfare source, 36,600 litres. Of this, it is estimated that 5000 litres is probably for hot water production. The value of the oil is approximately $23,800 (1983). A more normal fuel consumption, based on degree-day and furnace size data is 65,000 L, including that required for hot water heating. The cost would be $41,600 (1983).

The layout of the community in relation to the existing diesel plant and the space available, makes heat energy supply to the nursing station infeasible.

4.4.6 Band Garage

The band is currently constructing a central garage for the storage and maintenance of band equipment and storage of the band fire fighting equipment. It is located near the causeway to the mainland communities. It should provide good mechanical training opportunities for local residents (Figure 12).

The garage is equipped with a low pressure, hot water heating system. A central hot water boiler supplies hot water at 82°C to several unit heaters located throughout the building. The heat supply capacity of the boiler is 410,000 kJ/h.

The total estimated annual heating fuel requirement for this facility, based on the specification for the heating equipment is 40,000 L. At a 1983 fuel price of 64¢/L, the annual fuel cost would be $25,300 a.

The band garage is located such that moving a generating unit nearby might be considered for diesel heat recovery and supply if such a move were economical. It would appear less worthy of consideration than supplying diesel heat to the Bell Canada installation, Section 4.4.7.

4.4.7 Bell Canada

Bell Canada operates a remote telecommunication sites maintenance staff residence in Big Trout Lake. It acts as a base of operations station for Bell's staff in the north. Crews fly in and out to facilities as maintenance and upgrading are required.

The residence contains 12 bedrooms plus a large apartment for catering staff. It is maintained by outside staff year-round. It also contains a large recreation area, TV room, kitchen/dining room, laundromat, storage facility and mechanical room. It contains about 929 square metres of floor space.

The Bell facility is the closest installation to the Ontario Hydro generating units, about 180 to 240 metres. They are both on the same sideroad off the main road from the airport to the town (Figure 12).

The Bell Canada facility is heated by two 268,000 kJ/h oil furnaces and hot water is supplied by one 2.0 L/h oil heater. The total oil consumption in 1982/83 was 50,850 L at 59¢/L or $30,000. This reflects a somewhat milder winter than normal. It is expected that based on the degree-day and furnace data, the fuel requirement would be approximately 53,250 L or $31,400. Of this, 51,250 would be for space heating.

The Bell Canada facility represents the best alternative for diesel heat use in Big Trout Lake, and could be used to provide basic data for other future facilities.

4.4.8 Potential Applications

As in other communities, information was sought on planning in the community for facilities which might be able to use diesel by-product heat. This information was obtained largely from the 1982 Community Plan[19].

A community vegetable greenhouse facility was not among the items considered in the community plan, but its potential was briefly examined. It became clear through interviews with the local Co-Op operator and the Hudson Bay manager that there is insufficient market to justify its expense. Generally no more than $50-100/week of revenue could be expected, most from teachers, nursing station and environmental station staff.

Other applications also appear limited. Most future developments planned in Big Trout Lake appear to be expansions of existing facilities. These are infeasible because of the distance from the waste heat source. One major exception might be a hockey rink currently being studied. Details of the type and design details are unclear but its siting could be influenced by its heat demand. The others, a community centre, seniors residence and laundromat, are longer term items which may or may not receive further attention. At such time as plans become clearer, further consideration regarding by-product heat availability should be given.

4.5 Community Response to Electricity Generation and Diesel Heat Applications

The major item related to electricity generating activities in Big Trout Lake of concern to the band is the extension of service to the mainland communities. They indicated that other such matters would take second priority and would not be seriously considered before this. This is currently being undertaken by Ontario Hydro for the Department of Indian Affairs and Northern Development. Completion of this extension is expected in 1984.

The chief and members of the council indicated that they had been very serious about alternative energies, but as a result of their study by Middleton[10], were less interested in wood. They saw little economic savings for the band members.

The need to preserve their "relationship" with nature was mentioned several times. Their philosophy dictates that they should use the gifts of nature, but in as least destructive method as possible. This would tend not to favour wood based electricity generation which requires large areas of wood to be cut.

A second factor against wood was the council's expressed desire to reserve the best areas of wood growth, particularly that at Sandybank Lake, for the domestic requirements of the band. Although understandable, this decision would leave only the much poorer stands where growth is slow and considerable uncertainty over the effects of clear cutting on regeneration exist.

5.0 PIKANGIKUM

5.1 Community Background Data

Pikangikum is a native community of 950 persons (1982), located approximately 86 km north of Red Lake at latitude 51°N48' and longitude 93°W59' (Figure 15). It is situated on the eastern shore of Pikangikum Lake, on the Berens River. In 1982, there were 179 households in the community. Their current band chief is Mr. J.J. Suggashie. It is a part of the Pahabula Tribal Council.

Pikangikum is supplied by air from Red Lake. The commercial carrier is Austin Airways. The Ministry of Transportation and Communication maintains the local 1219 m gravel runway. Runway lights, a non-directional beacon, an operator and some heavy equipment have been provided.

A gravel road extends within 25 kilometres of the reserve, but is unlikely to be extended until the band rescinds a band council resolution aimed at not permitting its extension to Pikangikum. There is apparently interest in a winter road for limited access purposes.

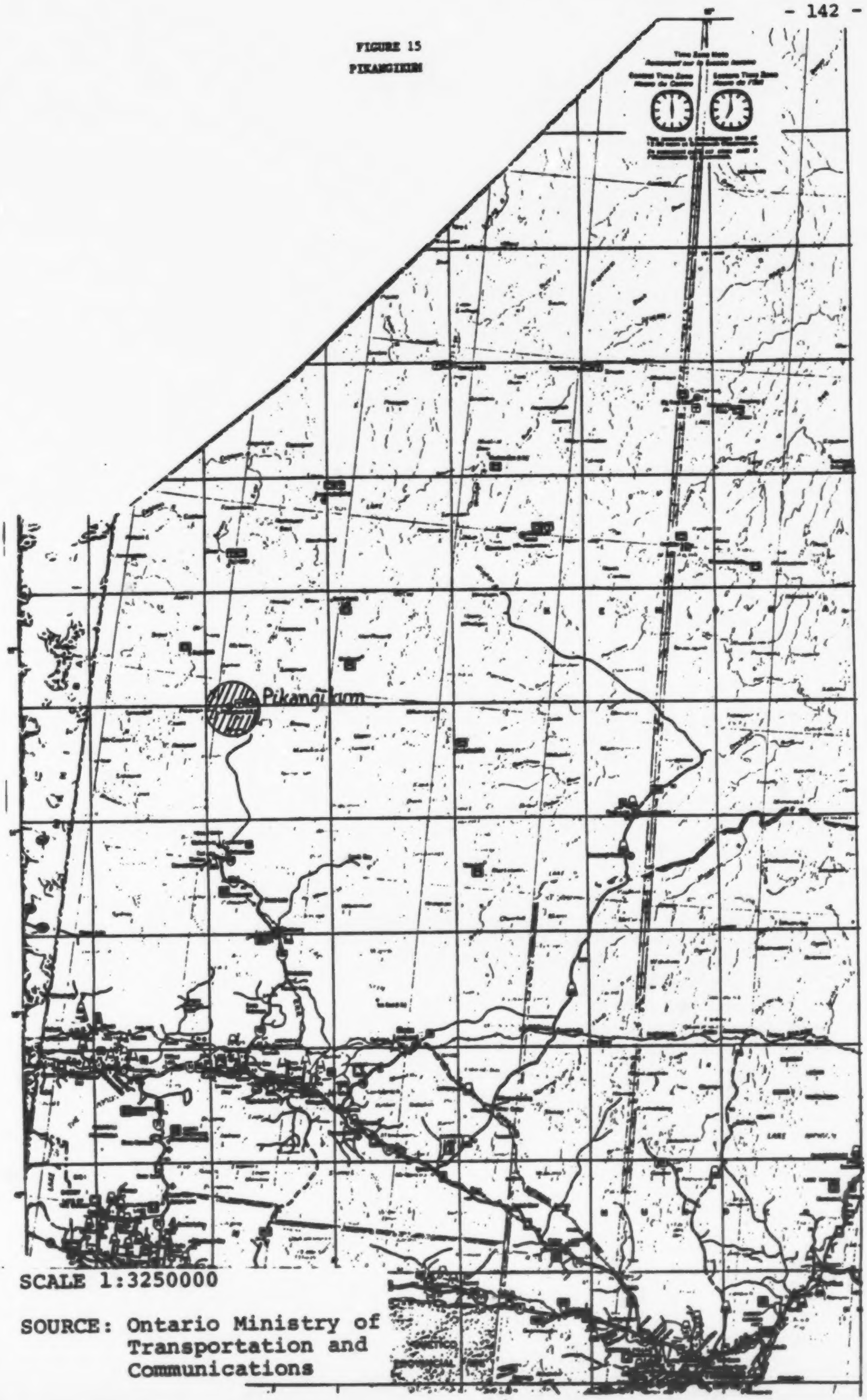
The community has considerably less economic activity than Sandy Lake or Big Trout Lake. Seasonal activities play a major role, including fishing and trapping. Public sector activities are the second largest area of economic activities. Numerous positions exist with various band, provincial and federal governments. Construction, utility and retail activities are relatively minor.

The major facilities in Pikangikum are largely governmental institutions. A summary of these taken from the R. Hedlin Associates study is:

- Primary School Buildings, six (one under construction)
- Teacherages, three (one under construction)
- Health and Welfare Nursing Station (511 m^2)
- Bell Canada Microwave Facility
- Hudson's Bay Store
- Co-operative Store
- Gideon Peter's Store
- Five churches
- MTC Airport Facility, Bunkhouse and Garage
- Ontario Hydro Diesel Generator Installation

FIGURE 15

PIKANGIKUM



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SOURCE: Ontario Ministry of Transportation and Communications

Weather data from Red Lake is used for Pikangikum.

Mean Temperature	High	Low
January	-15.5°C	-26.5°C
July	23.7°C	12.6°C

Annual Average Temperature 0.7°C
January 2 1/2 % Design Temperature -35.5°C
Degree Days 6,333°C

Annual Average
Wind Speed 10.9 km/hr

Heavy equipment in the Pikangikum is almost exclusively MTC owned. The band only recently purchased a new $200,000 back-hoe/front end loader. This is its first piece of such equipment.

The MTC has two bulldozers; a Trojan Model J100 and a Caterpillar D6C, a Champion D562 Grader, two tandem dumptrucks, a roller and a grader. According to an MTC source in the Thunder Bay Airports Section, equipment can be rented. A D6 bulldozer is $63/hr. A dumptruck is $38/hr. A grader is $42/hr and a 1.52 m^3 front end loader $50/hr. In addition, the operator's time cost $15.55/hr and his assistant $14.23/hr. Overtime rates are $19.60 an 17.93/hr respectively.

As in all these communities, the major fuels used are wood, fuel oil and gasoline, with some propane use.

In 1981, all native households used wood for heating. Each required about 9 ODMg for a community total of approximately 1633 ODMg per year.

Fuel oil is used largely for institutional space heating, heavy equipment operation and diesel electricity generation. According to the R. Hedlin report the 1981 heating requirements were approximately 105,000 L, at between $0.37 to $0.505/L.

Gasoline is sold largely for snowmobile or outboard motor use. The R. Hedlin report indicated that in 1981, approximately 210,000 L were sold. No price data was available. In 1983, the price is approximately $1/L.

5.2 Electricity Supply

Facilities

Electricity in Pikangikum is supplied from a central generating facility operated by Ontario Hydro, located adjacent to the MTC facilities at the airport (Figure 16). The facility contains three diesel generator sets. Two are 125 kW machines and the third is a 175 kW unit.

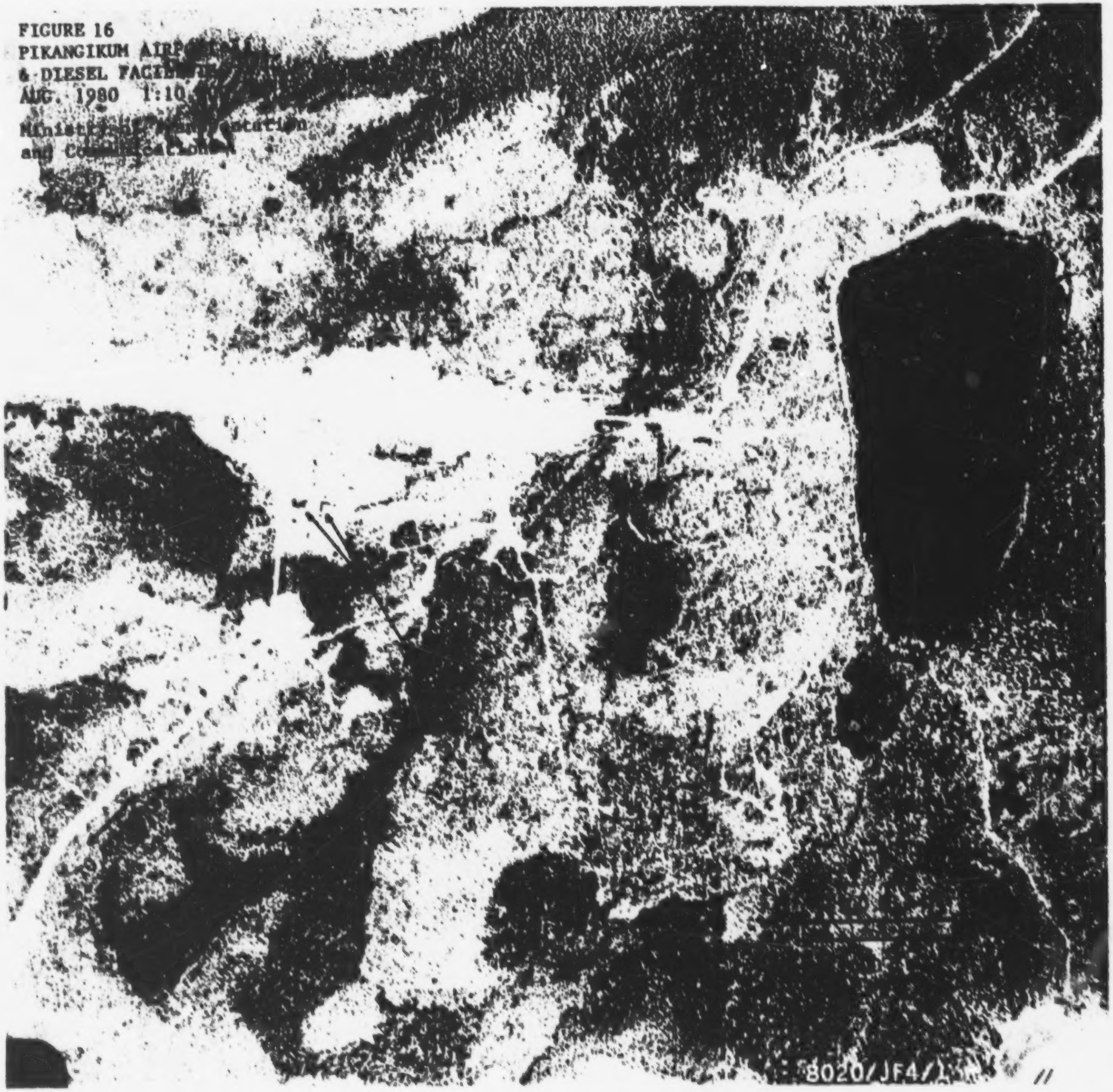


FIGURE 16
PIKANGIKUM AIRP[illegible]
& DIESEL FACI[illegible]
AUG. 1980 1:10[illegible]

Minist[illegible]ortation
and Co[illegible]cations

Units 1 and 2 are 125 kW, 156.25 kVA, 1800 rpm machines. They are equipped with turbo-charged, six cylinder, direct injection Allis Chalmers engines and Bosch SG hydraulic governors. The generators are Newage-Stamford units rated for 180 kVA. Both units in parallel are required to meet the 1983 peak load.

Unit 3 is a 175 kW, 218.75 kVA, 1800 rpm machine equipped with a turbo-charged, six cylinder, direct injection Caterpillar 3406 engine and DYNA-1 Barber Coleman Electronic Governor. The generator is a Newage-Stamford unit rated for 250 kVA. This unit is capable of meeting most of the communities' requirements, but cannot now meet the annual peak load of 194 kW in 1983.

Fuel

Fuel is delivered directly from supply aircraft into the Ontario Hydro storage tanks. As in other sites, it is delivered in approximately 4100 L loads. The 1983 estimated average delivered fuel cost is $0.50/L. Of this, 28¢ is the base price and 20¢ the delivery charge and 2¢/L covers miscellaneous expenses. The 1982 and 1981 delivered costs were 44¢/L and 37¢/L.

The 1982 total fuel consumption and cost were 267,730 L and $117,018 up from 250,508 L and $93,274 in 1981. Generating fuel efficiency was 2.64 kWh/L up from 2.52 kWh/L in 1981.

Production

Total production by Ontario Hydro units in Pikangikum in 1982 was 707,300 kWh, up from 632,300 kWh in 1981. The peak in 1982 was approximately 194 kWh at the end of December 1982. (January 1983) versus 144 kW in 1981 (December 1981/January 1982) (Figure 17).

The average load to average peak load for 1982 was 80.74 kW/137.67 kW or 0.586. This was down from 72.18/109.25 or .661 for 1981. This is not unexpected since the peak load would be expected to increase more than the average load since the night time load is not expected to be affected as significantly.

Costs

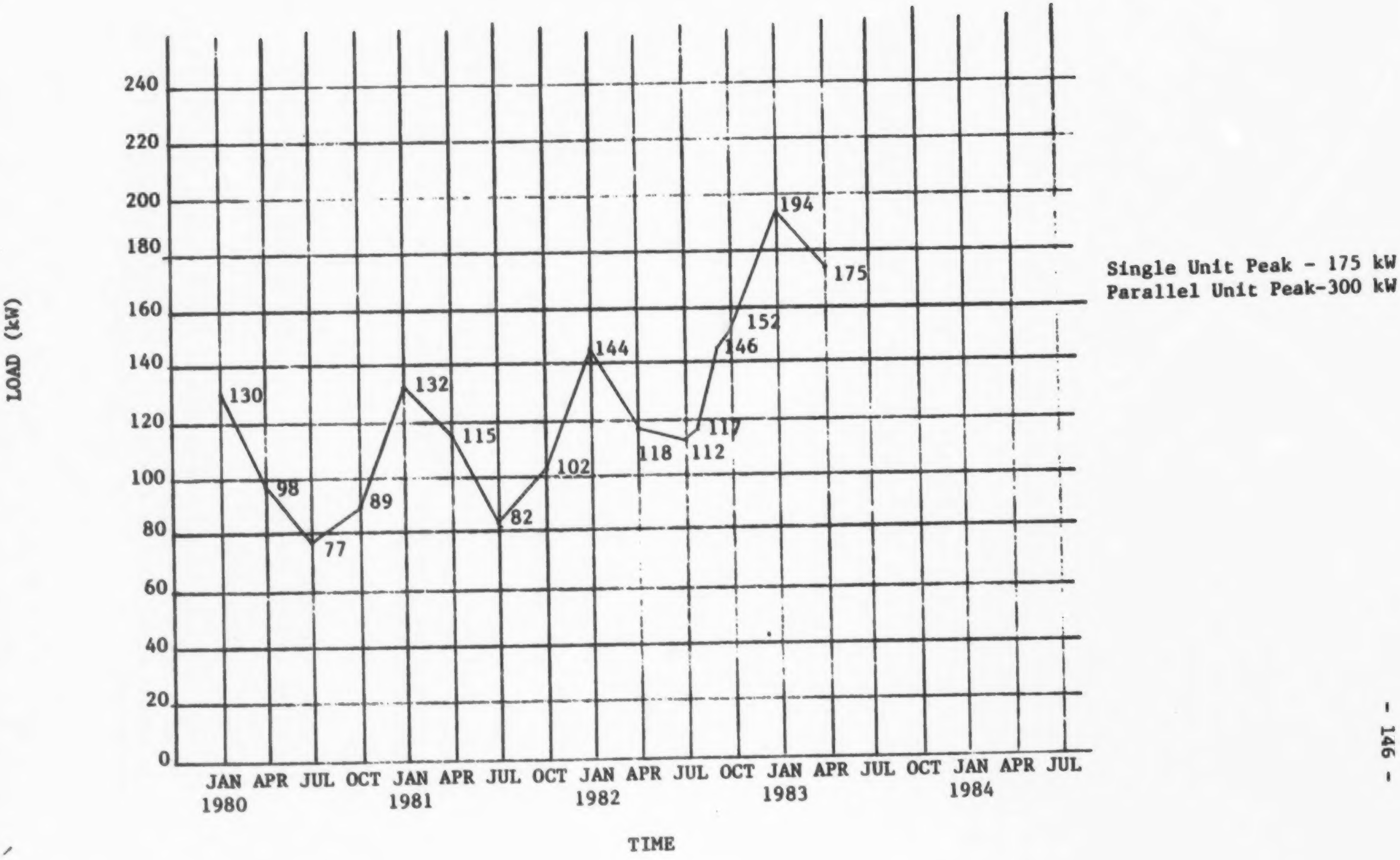
The total cost of production and distribution of electricity in Pikangikum in 1982 was $246,098. In 1981 the total cost was $224,757.

Diesel Heat Availability

At full load, the Pikangikum units can produce approximately 115 to 120 kW or 414,000 to 432,000 kJ/h of coolant heat. A rough estimate of the annual diesel heat available is 1750 GJ or 45,100 L of fuel oil equivalent.

FIGURE 17

PIKANGIKUM PEAK LOADS
(1 - 175 kW and 2 - 125 kW Units)



Future Plans

Ontario Hydro has preliminary plans to replace two of the machines in Pikangikum. The first would be a 260 kW unit in 1984/85 and the second a 400 kW unit in 1985/86.

The installation of these new units will result in three graduated units, a 175 kW, a 260 kW and a 400 kW, in order to improve efficiency. A remote radiator system and a secondary heat recovery system are planned for the retrofit to improve unit efficiencies and operability and to provide flexibility in the supply of diesel heat. A microcomputer control system would be included to automate the system in the most efficient and reliable manner. It will also provide automatic data recording.

As in the other sites, current plans for new units, automation and the desire to maintain a centralized production facility, do not favour the development of systems requiring decentralization. Thus, a single unit located near a heat source operated at base load would face some opposition.

Other Generation

There are, with the exception of a 13.2 kW, two cylinder stand-by generator at the nursing station, no other large generators in the community, nor are there any plans at present for such facilities.

5.3 Alternative Generation Opportunities

Ontario Hydro's Hydraulic Studies Department in 1979 identified four potential small hydraulic sites between 8 and 24 km from the community. The first site is located on the Berens River at the outlet of Pikangikum Lake, about 8 km west of the community. It has a head of about 3 m. The second is downstream of it and has a head of 2.5 m. If a dam were constructed, a combined head of 5.5 m might be feasible (600 kW). The third site is 11 km southeast of Pikangikum. It is a 3.4 m falls and could produce sufficient power for the community. The last site is Mikarami Fall, 27 km east of Pikangikum. With a head of 9 m, it would have an approximate capability of 900 kW.

The scope of this study is largely limited to wood generation alternatives. Although it would appear that some hydraulic potential might exist, the costing of this arrangement is currently beyond the scope of this study.

Wood Resource Base

Pikangikum is within that area of the province of Ontario for which the Ministry of Natural Resources maintains Forestry Inventory Data. The latest MNR data in the Pikangikum area was developed in 1977. In addition to this, PME conducted an evaluation of forestry operations in Pikangikum in 1972.

Of major significance to the evaluation of forest resources is the occurrence of major fires in the Pikangikum since the last Ministry of Natural Resources Forest Resource Inventory Mapping in 1977. Much of the forest on the reserve and to the east and west of it were destroyed. Figure 18 presents a rough idea of the scope of the fires.

It is evident, based on the map in Figure 18 and a site visit that wood is not a viable fuel for electricity generation at this time. Wood resources for community heating would be threatened. This would be unacceptable to the band. To get the wood necessary, would require much further transport and increase costs.

5.4 Community Heat Users

In terms of the facilities in the community, which could use waste heat from either a diesel or wood based electricity generating system for space or water heating, the choices are relatively few. The major facilities are the Hudson's Bay Store, the nursing station, the Ministry of Transportation and Communication airport facilities, and the school. A brief description of each follows.

5.4.1 Hudson's Bay

The Hudson's Bay Store is relatively isolated from the community and is considerable distance from the existing diesels (Figure 19). There is currently only one phase power to that location.

The Bay Store has a 168,000 kJ/hr (net), 5.7 L/h oil fuelled furnace. Fuel is delivered to the store by a fuel cart, approximately 4100 L per trip. They pay bulk fuel rates like Ontario Hydro's plus 2.4¢/L for delivery from the airport.

The Bay's average heating demand is estimated to be approximately 14,500 L/a based on the degree-day approach. Actual data were unobtainable. The total cost would be at 53¢/L(1983), approximately $7,685. In addition there are two residences on site, each requiring approximately $5,000 worth of fuel oil for a site total of approximately of $20,000.

The Bay Store is not a candidate for consideration. Moving the station or a unit would be infeasible.

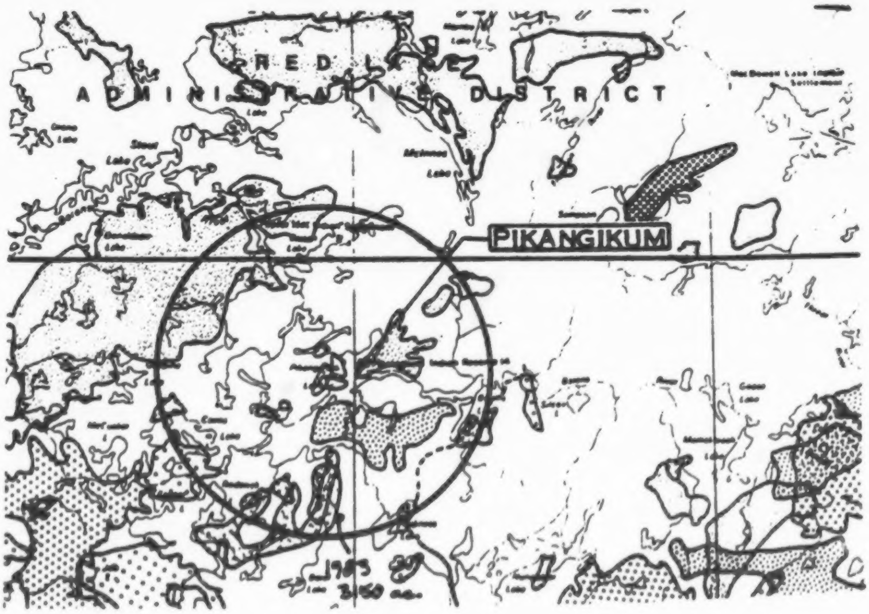
5.4.2 Nursing Station

The nursing station is located at the southwesterly most corner of the reserve (Figure 19). It is a 511 m^2 facility staffed by four nurses. A garage, fuel storage and visiting staff house are also provided. There is very little additional space available. The facility is surrounded by other housing or community facilities.

The station is heated by three Findlay, forced air, 148,000 kJ/h (net) furnaces. Hot water is supplied by a 175,000 kJ/h, oil fuelled hot water heater.

FIGURE 18

FOREST FIRES IN THE
PIKANGIKUM AREA



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SOURCE-ONTARIO MINISTRY OF
NATURAL RESOURCES

LEGEND

░	1920 — 29
░	1930 — 39
▨	1940 — 49
▦	1950 — 59
☐	1960 — 69
░	1970 — 79
■	1980
▨	1981

The annual fuel oil consumption at the Pikangikum nursing station in 1982/83, according to Health and Welfare Canada, was 24,870 L. This is drastically different from the 45,460 litres (1981), reported in the R. Hedlin report[11].

Using the furnace size and degree-day approach, we estimate the heating requirements to be 42,700 L. An additional 4500 L may be required for hot water heating. The total 47,200 L is very close to the R. Hedlin values. At 53¢/L, the cost would be approximately $25,000/year.

The nursing station, due to its distance from the existing facilities and the relative congestion of the area, is not considered further.

5.4.3 Pikangikum School

The Pikangikum school consists of three existing school buildings, two portables and two existing teacherages containing a total of five housing units (Figures 19 and 20). Two additional buildings, a two room school and a teacherage apartment complex, are currently under construction. Several other changes/additions/demolitions may be considered in the near to mid future. It is difficult to assess the future status of this facility or its eventual layout at this time.

The main school building contains approximately 46.45 m^2 of interior space. Heat is provided by a hot water system incorporating an Arco Flame L American Standard hot water unit (71°C). No further data was available on the school equipment. The heat required was estimated on the basis of its similarity to the Big Trout Lake old school building. A value equal to eighty percent of the Big Trout requirement was assumed. Thus, 348,000 kJ/h or approximately 30,000 L a of fuel oil was assumed.

The north, two room school building contains about 19.35 m^2 of floor space and is heated by a 169,000 kJ/h oil furnace. The annual fuel use is expected to be about 13,000 L. This building may be demolished in the near future. The three remaining school buildings would consume about 13,000 L between them. The two older teacherages were inaccessible at the time of my visit. One was supposedly steam heated and the other hot water. It is likely that their total consumption would be about 22,000 L.

The new school buildings, the two room school and the four apartment teacherage, might be expected to consume 53,000 L/year of fuel, this based on the rating of the six, 102,000 kJ/h furnaces to be installed.

BELL CANADA
BAND OFFICE
OPP

As the school facilities now stand, the expected fuel oil consumption and costs are:

	L/a	Cost at 53¢/L(1983)
Main School	30,000	$15,900
North School House	13,000	6,900
Three Small School Buildings	13,000	6,900
Teacherage Townhouses	22,000	11,700
New School Building	17,000	9,000
New Teacherage Apartment	36,000	19,000
TOTAL	131,000	$69,400

The future of each of these particular installations is difficult to predict. The main school may have a large addition added while the north school house and the small school buildings may be demolished. Even the new two room school may be relocated somewhere on the site and converted to a teacherage.

The school is the most obvious candidate for a by-product heat facility if the facility were located nearby the generator. There is however, considerable distance, at least 2 kM, between them at present. If considered, it would likely be more economical and practical to relocate the generators than to transport the heat by pipeline.

The only building one would consider serving at this point would be the main school, the remaining are small individual units or their future is at best uncertain.

5.4.4 MTC Airport Facilities

As in Sandy Lake, the closest facility to the existing diesel generating station is the MTC airport garage and bunkhouse. (Figure 16).

The maintenance garage has two small, forced air, oil fuelled furnaces, each at 168,000 kJ h, but according to local MTC personnel only one is operated, the other acts as a back-up. The bunkhouse has a single 123,000 kJ h, forced air, oil fuelled furnace.

The maintenance garage and bunkhouse are heated to normal levels only when occupied, but at reduced temperatures (10°C) when unoccupied. As previously indicated, no fuel consumption data was available from MTC's airports section in Thunder Bay. For the purposes of this study, estimates had to be determined based on degree-day data, furnace data and estimated levels of occupancy.

A revised value of 4500°C and 5556°C degree-days was assumed for the garage and bunkhouse respectively. Based on this information, approximately 9400 L/year at a cost of $5,000 is required for the garage and 8500 L/year at a cost of $4,500 for the bunkhouse. These vary considerably with earlier Hedlin[11] numbers of 9092 L.

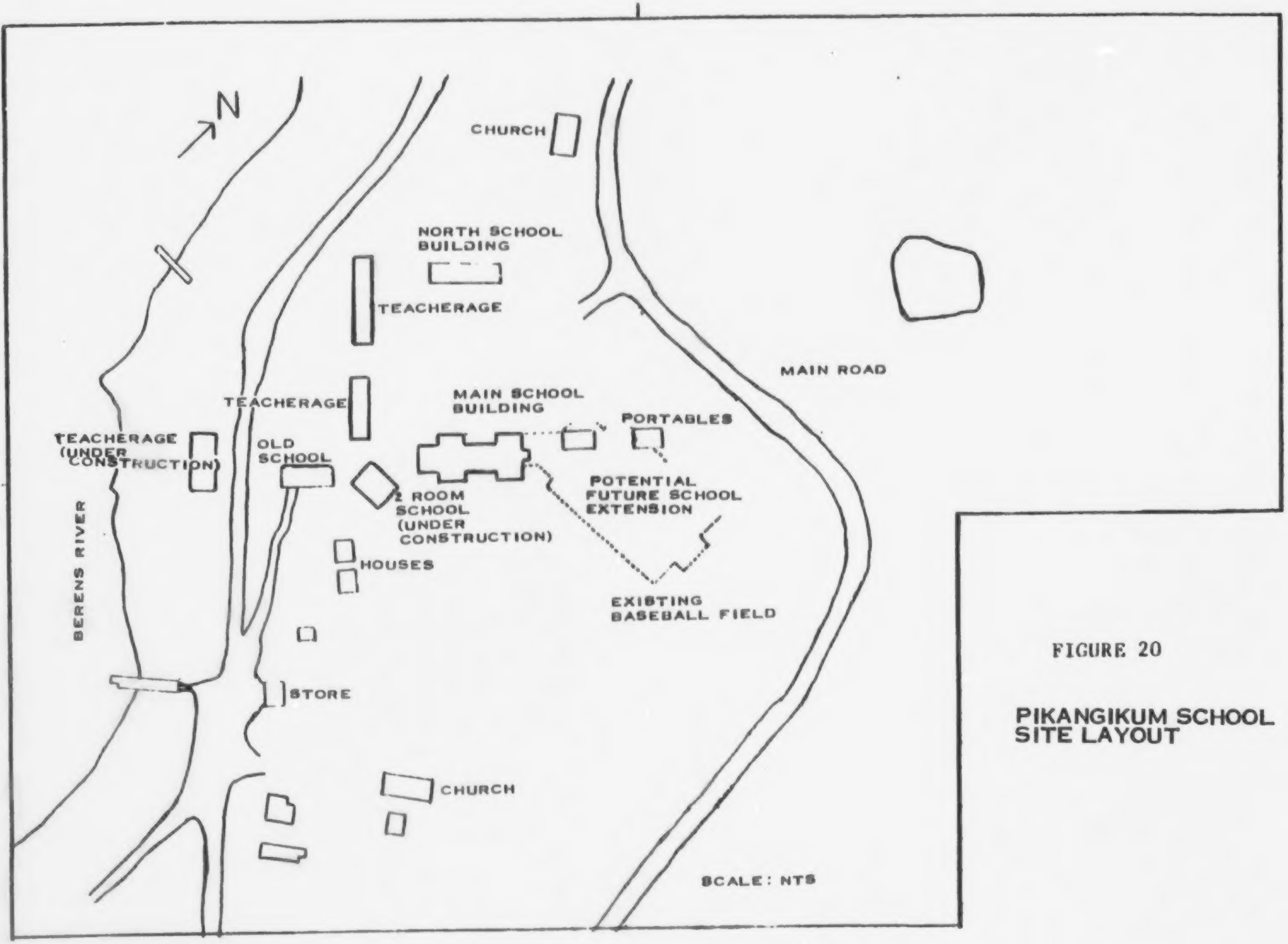


FIGURE 20

PIKANGIKUM SCHOOL SITE LAYOUT

This installation is similar to that at Sandy Lake, but requires less heat at a lower fuel oil cost and requires more heat delivery piping.

5.4.5 Potential Applications

At this stage in time, there appear to be no major plans for community facilities. The major changes to the community are likely to centre around the school and housing, but there is considerable uncertainty about those plans even with DIAND officials[18].

It may be that as in other reserves applications such as laundromats, motels or community centres might be considered. There are however, no current plans. In addition, siting these facilities near the diesel heat source would cause considerable inconvenience to local residents.

As in other locations, the market for a greenhouse operation make it infeasible. The local Bay manager indicated that the local market is less than $50/week.

5.5 Community Response to Electricity Generation and Diesel Heat Applications

Pikangikum, as a result of fires on the reserve, is not in a position to consider wood systems. This was confirmed with Chief Suggashie.

The band has no particular comments regarding the supply of waste heat from the Ontario Hydro diesels. The Chief indicated that provided that all necessary steps were taken to minimize noise effects, the diesels could be moved nearer the school to provide it with diesel heat.

6.0 ARMSTRONG

6.1 Community Background Data

Armstrong is an unincorporated, northern community of about 800 persons (1982) in about 126 households. It is located about 250 km north of Thunder Bay on the Canadian National Railway line at latitude 50°18'N, longitude 89°2'W (Figure 21). It is a major railroad division point and a service centre for some of the area's timber cutting operation.

Armstrong is accessible by road (Hwy 527-250 km to Thunder Bay) and rail (CNR) and car. The MTC owns an airport facility with two landing strips of 1128 m and 896 m. It is now relegated to a more or less summer, daytime operation only.

Armstrong's remote status is related mainly to its dependence on diesel generated electric power rather than grid power. It is similar in that sense to other rail communities, but is much larger, more prosperous and more accessible.

The community is served by a local Chamber of Commerce, headed by Jack Lundstrom and a local Services Board.

The local services board is elected for a one year term of office. It is responsible for basic municipal services such as garbage collection and firefighting services. Its very make-up, a one year term, and limited powers, make its usefulness in determining the course of Armstrong's future very limited.

The Chamber of Commerce has been very active in trying to stimulate permanent growth. In 1981/82 in conjunction with a consultant, Jellicoe Resource Associates, the Chamber of Commerce undertook a study to examine growth opportunities for Armstrong[13]. Most of the recommendations of the report hinged on two assumptions; growth in the forest industry in Ontario and cheaper power. The current situation in both cases does not favour Armstrong.

Nevertheless, relative to the other native communities examined in this study, Armstrong is very well off. It has considerable economic activity, including:

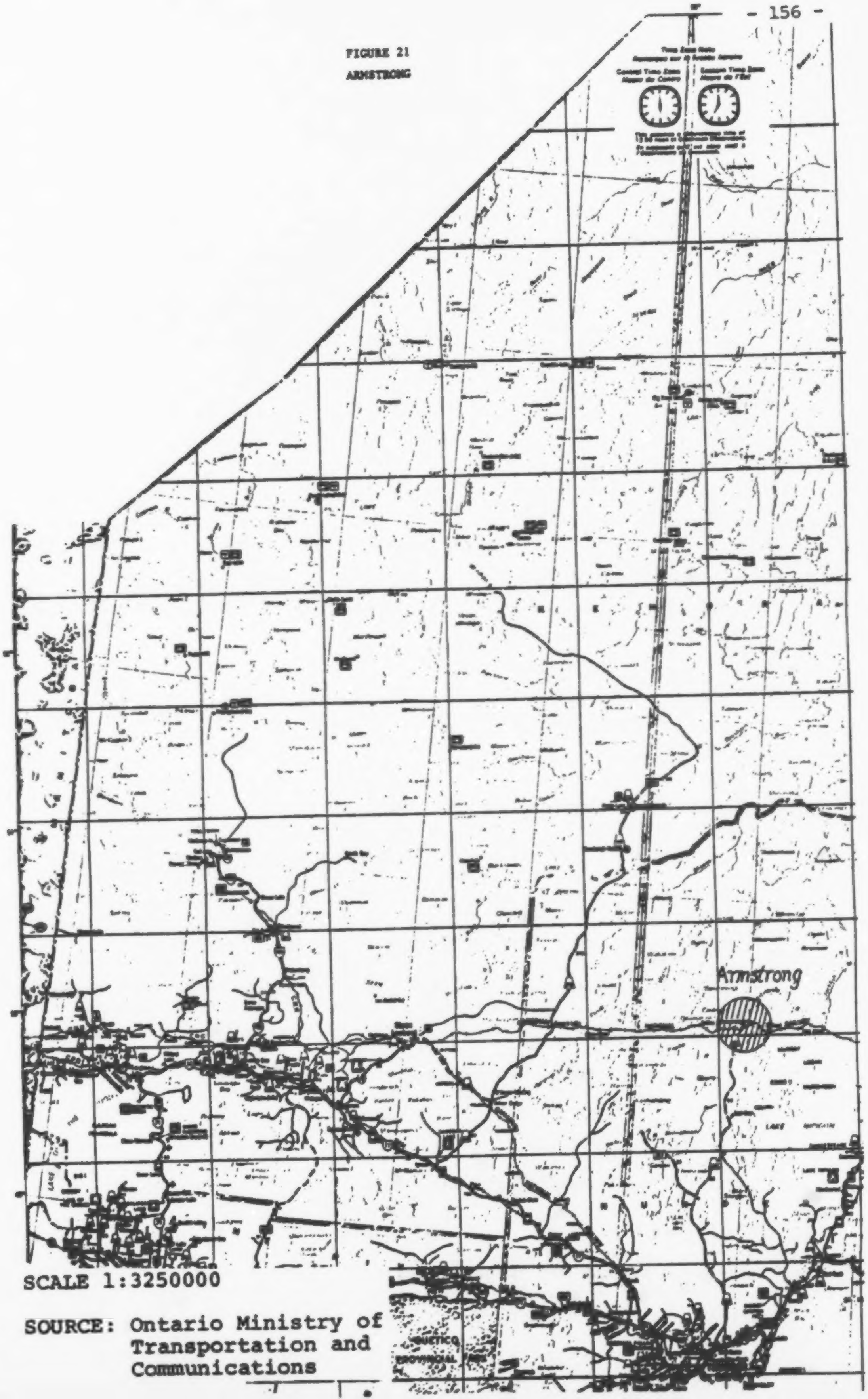
- D&L Estates, a motel and restaurant complex (formerly a DEW Line Radar Base)
- King George Hotel

CN division point and rail crew bunk

- Mrakic Bus Line
- MNR field office and garage facility
- Laybourne & Son Trucking

FIGURE 21

ARMSTRONG



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SOURCE: Ontario Ministry of Transportation and Communications

- Northern District School Board Office
- Tourist Outfitters
- Armstrong Public School
- Numerous wilderness camping, hunting, fishing outfitters
- Laybourne Esso Fuel distribution
- J&J General Store
- Wilderness Restaurant
- OPP Office
- Great West Timber Field Office
- Great West and Nym Lake Forestry Operations and Timber Hauling

Despite this relatively well developed economic situation, the community seeks additional opportunities, particularly those less subject to the economic ties of the forestry industry. Nevertheless, as the Jellicoe Resource Association report indicates, Armstrong's future will continue to depend on the forest industry. Almost all the opportunities for future growth identified: a tree nursery, a maintenance garage, a fuel wood project, a small log saw mill, and wood fuelled electricity generation, depend on the forest industry.

The major existing facilities in the town are:

(a) D&L Estates
(b) CN bunkhouse, station
(c) Armstrong School
(d) MNR Field Office Complex
(e) Tree Nursery Greenhouse Complex
(f) Ontario Hydro Generating Station

Weather data for Armstrong is collected at the MNR facility and some is taken from data from other communities.

Mean Temperature	High	Low
January	-14°C	-28.2°C
July	23.6°C	8.6°C

Annual Average Temperature	-1.1°C
January 2 1/2 percent Design Temperature	-39°C
Degree-Days (C°)	6921
Annual Average Wind speed	13.1 km/hr

Heavy equipment in Armstrong is almost exclusively, privately owned, but details cannot readily be determined on the quantities and type. These will vary directly with ongoing timber operations in the Armstrong area. Great West Timber and Nym Lake Timber Limited are major operators in the area and have considerable numbers of equipment in the forested areas from skidders to tree harvesters to large tree hauling trucks.

Nym Lake Timber is a local forest harvesting contractor and is available to supply wood fuel requirements. They are currently harvesting 90,000 ODMg a (100,000 cords) in the Mattice Lake area, south of Armstrong under contract to Great West Timber.

The major fuels used in Armstrong are wood, fuel oil, propane and gasoline. Exact values are unavailable. Unlike the remote communities numerous sources, suppliers and private concerns are involved. For the purposes of this study, only those values under community heat users, Section 6.4, will be examined.

6.2 Electricity Supply

Facilities

Electricity supply to most of Armstrong is from an Ontario Hydro central generating station, equipped with two independent, 350 kW diesel generators. In addition, D&L Estates have their own diesel engine generator capability, supplying all facilities in their boundary, and CN has two, older 250 kW diesel generators which they maintain for back-up to the Ontario Hydro units for their own needs. It may be that as load in Armstrong grows, these CN units will be more frequently used for CN service.

Ontario Hydro's generating facilities (Figure 22) consist of two, Commins KTA1150G, turbo-charged diesels with Kohler generators. The units were originally rated at 350 kW, but now are considered to have a 335 kW rating. They are now not able to be paralleled, but could be with the installation of the necessary synchronizing equipment. The engines themselves are equipped with Barber Coleman DYN1.1004-2 Electronic Governors suitable for paralleling. These units have independent external heat exchanger coolers.

Fuel

Fuel is currently delivered via fuel transport truck from Thunder Bay or CN railcar unloading system, directly to the Ontario Hydro storage tanks. These three 91.1 m by 3 m diameter containers can hold approximately 65,800 L each.

Total fuel consumed by Ontario Hydro in 1982 and 1981 respectively, were 507,194 L and 572,396 L at $0.27/L and $0.23/L. The delivery charge was minimal. The total fuelling cost was $139,020 in 1982 and 132,796 in 1981.

Although fuel consumption appears to have dropped in 1982, production of power was up significantly from 1,463,000 kWh to 1,610,500 kWh, approximately 10 percent. The apparent contradiction is understandable since the 1982 reported efficiency was 3.18 kWh/L (29.6 percent) versus a 1981 value of 2.56 kWh/L (23.8 percent).

In 1983, the average Ontario Hydro delivered diesel fuel price in Armstrong is expected to be 30¢/L. Assuming a rough 10 percent increase in generation, the total fuel consumption would be about 628,921 L assuming an efficiency of 2.75 kWh/L (25.6 percent) at a cost of $188,700.

Production

Total production by Ontario Hydro's Armstrong units in 1982 was 1,610,500 kWh, up 10 percent from 1,463,000 in 1981. The peak for both years was 330 kW in December (Figure 23).

The average load to average peak load for 1982 was 184 kW/257 kW or 0.716. This was up from 1981 levels of 167 kW/257 kW or 0.649. Unless something is done to increase the peak load capability of the Armstrong installation, this ratio is likely to increase, as it indeed appears to be doing in 1983.

Costs

The total cost of production and distribution in 1982 in Armstrong was $275,109. In 1981, the total cost was $213,117.

Diesel Heat Availability

At full load, the Armstrong units can produce approximately 240 kW or 864,400 kJ/h of coolant heat. A rough estimate of the annual diesel heat available is 4156 GJ or 107,300 L of fuel oil equivalent.

Near Term Future Plans

Ontario Hydro currently has no specific plans for improvements in Armstrong. Before uprating could take place, the Province of Ontario and Ontario Hydro would have to resolve who is responsible for the costs incurred.

The Ontario Ministry of Energy has expressed considerable interest in demonstrating a wood gasification/diesel genset facility in Armstrong. They currently are partially funding such a demonstration by Petro Sun in Ramsey. The unit is operated on a profit motive basis as a private utility. A similar arrangement is being looked at for Armstrong by Petro Sun where the Ramsey unit would be moved to Armstrong and Ontario Hydro would purchase power from Petro Sun.

The Ministry, in conjunction with EMR, are currently funding a study which may review, in some detail, the forest biomass and peat resources near Armstrong in support of a biomass based generation application.

RMSTRONG
IR

Other Generation

CN did not operate their diesel units sufficiently to obtain data. They took their power from Ontario Hydro's system.

D&L Estates have two diesel units, a 100 kW and a 175 kW machine. These units supply all of D&L's electricity demands. It is expected that the 100 kW machine will soon be replaced with a 250 kW unit. The peak load exceeds the capability of the smaller unit 4-5 months of the year. There are no interconnections between the Ontario Hydro and D&L systems.

No estimates of D&L's fuel usage for electricity generation or heating were obtained. As a wholly, privately owned establishment with both heating and electricity generation capability, it was felt that such a study could be undertaken internally by D&L.

6.3 Alternative Generation Opportunities

The alternatives to diesel generated electricity in Armstrong are bulk system power, supply from a hydraulic project called the Little Jackfish or wood based systems. Bulk system connection is not planned, and the Little Jackfish, has been indefinitely postponed. Excess generating capacity on the Ontario Hydro system, reduced levels of increases in demand and its economics relative to other generation alternatives were the reasons for its suspension.

Wood as an alternative electricity generation feedstock is nothing new to Armstrong. Preliminary studies were undertaken by the Chamber of Commerce, and Ontario Hydro. In both cases, the results were not encouraging. Wood based generation appeared to be more expensive than diesel systems, certainly not much less expensive.

A great deal seemed to depend on the capital requirements of the wood systems and the operator requirements. Both were stumbling blocks in past studies.

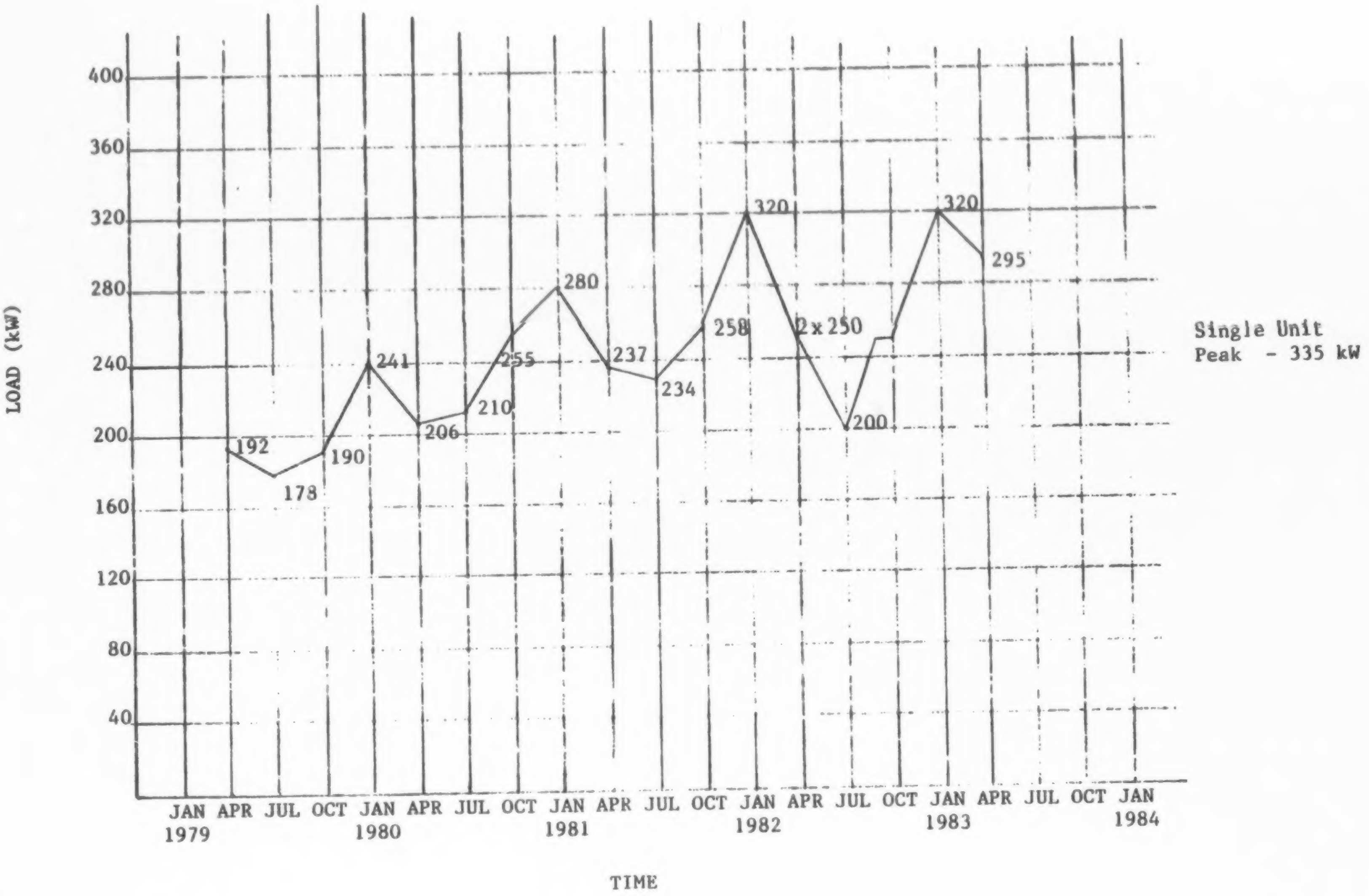
Wood Resource Base

Wood resource data for the area surrounding Armstrong is excellent, although somewhat dated. Studies of fuelwood and timber potential, is inventoried by the Ministry of Natural Resources on a regular basis as part of the process of Forest Management in this area.

Forest resources in the Armstrong area are largely under license to Domtar in the Domtar Working Circle and the Armstrong Crown Management unit. Great Lakes Paper also have an extensive license in the area. Great West Timber has extensive operations ongoing in the area under a third party agreement with Domtar. Softwoods are cut for timber and shipped to their Thunder Bay mill. As a part of the arrangement, Great West also supplies some chips to Domtar for their pulp facility. Nym Lake Timber are sub-contractors to Great West. They are currently removing approximately 91,000 ODMg (100,000 cords) of wood per year, largely softwood, in the Armstrong area (Figure 24).

FIGURE 23

ARMSTRONG PEAK LOADS
(2 - 335 kW)



In terms of this assessment, a brief review was made of hardwood resources within a six and eight kilometre radii of Armstrong (Figure 24). Raw computer data was provided by the Ministry of Natural Resources. It was found that there were sufficient hardwood stands (3035 hectares) to supply a 300 kW unit running at 10 percent efficiency 8760 hours per year. About 60 hectares of existing poplar stands would be required per year. Based on an allowable cut calculation and 85 year rotations, the area required would be 2233 hectares initially and 2960 hectares eventually. By assuming a larger working circle and utilizing poorer quality softwood stands, one could easily provide on a renewable basis, sufficient hardwood fuel. The average hardwood stand density is 78.5 ODMg/ha (35 cords/acre).

The hardwood resources in the vicinity of Mattice Lake where Great West Timber and Nym Lake Timber have ongoing softwood operations and near a potential heat user, the tree nursery, were also examined. The average distribution of hardwoods over a 2815 hectare area was 42.8 ODMg/ha (19.1 cords/acre). The average growth rate was 0.69 ODMg/ha/a (0.308 cords/acre/year) (Gross Total Volume). On this basis, one would require the hardwood taken from an average 107 hectares, and on an allowable cut basis would require 3642 hectares initially and 6475 hectares eventually. This does not allow for the harvesting of other non-commercial softwoods. In many of these stands the poplar and birch species are minor components. The major activity would be harvesting commercial timber wood.

In view of the extensive operations in the Armstrong area, it is unlikely that wood supply would initially be a problem. Nym Lake Timber have expressed a positive response to such a proposal operated in conjunction with their timber operations. The difficulty may lie in obtaining some guarantee of long term supplies. The Ministry of Natural Resources have indicated that reserving areas of woodland for fuelwood would not presently by considered. Fuelwood would thus be subject to the competitive marketplace if other uses develop for the hardwood and non-commercial species contemplated for use. Probably the most secure supply contract that one could hope for is five years.

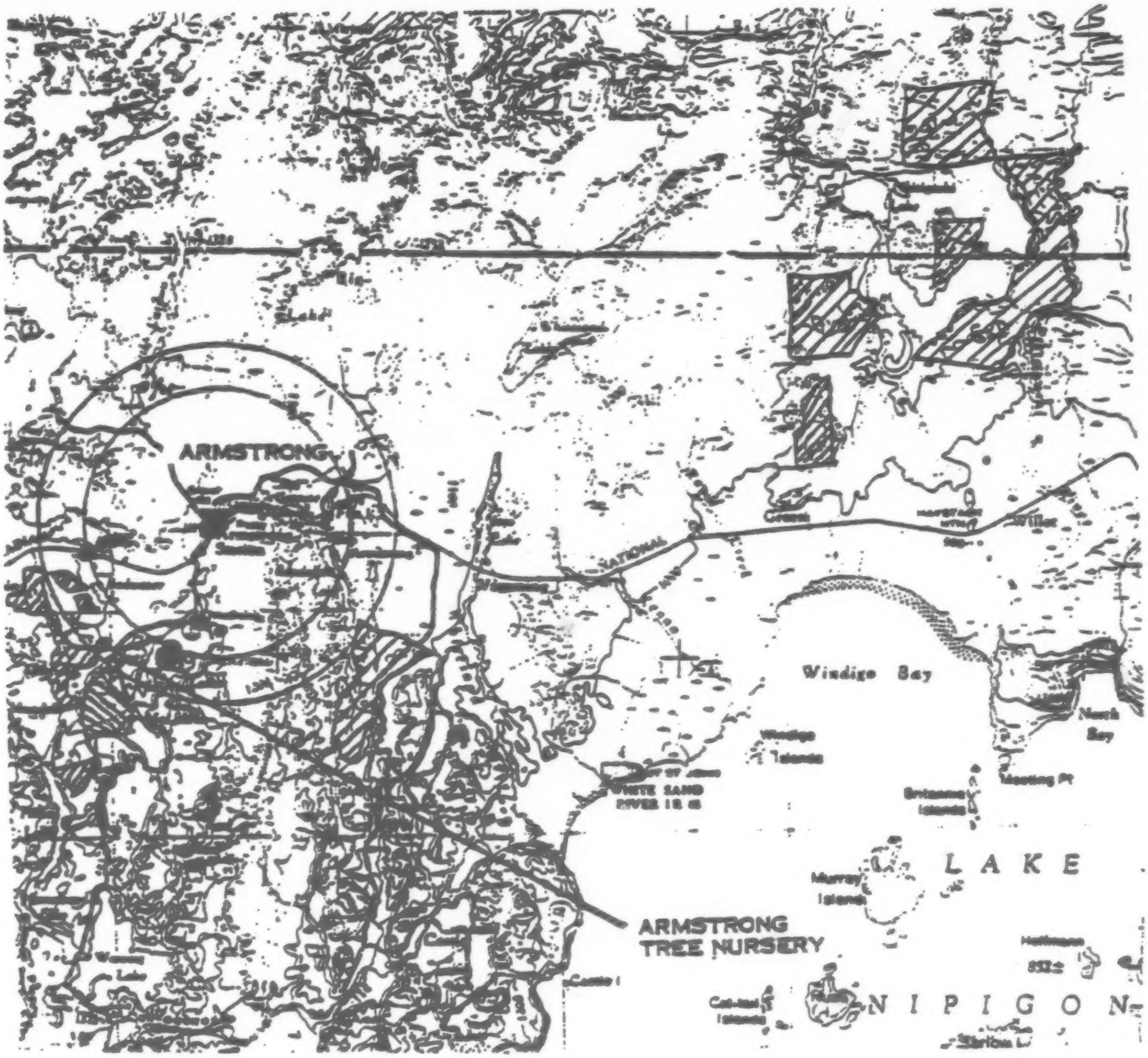
6.4 Community Heat Users

The major heat users in the community (Figure 22) are D&L Estates, MNR's field office, Armstrong School and CN's bunkhouse and station. Other government facilities include the OPP office, and the Northern District School Board. A new facility being constructed is a tree nursery.

Additional facilities considered in Jellicoe's development report included an industrial park maintenance garage and small log sawmill.

6.4.1 D&L Estates

D&L Estates is a privately owned motel/restaurant complex having its own diesel electricity generating facilities. No further work was conducted on this facility as it is a wholly privately owned and operated facility.



● - Recent Forest Fires

○ - Armstrong Forest Resource Assessment Areas

▨ - Existing or Recent Forest Operations by Great West Timber or Nym Lake Timber

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FIGURE 24

ARMSTRONG FOREST RESOURCE ASSESSMENT

6.4.2 Armstrong School

The Armstrong School is centrally located within the community. It consists of a six classroom main school building and three portable classrooms (Figure 25). The school is for primary education only. The total floor area in the main school building is approximately 929 m^2. Each portable contains about 65 m^2 of floorspace.

Heating for the main school building is provided by four furnaces in two mechanical rooms. Two furnaces are located in the interior of the school, in the southern half. These are both 220,000 kJ/h forced air furnaces. A small electrically heated hot water heater is also in this room. The second furnace room is on the west exterior wall near the rear of the school. It contains two forced air 265,000 kJ/h furnaces and a 318 L 245,000 kJ/h hot water heater.

The 1982/83 fuel oil deliveries totalled 30,961 L. The vast majority of this was for space heating. According to degree-day furnace data calculations the normal annual space heating fuel requirements would be expected to be in the neighbourhood of 41,000 L, assuming one of the furnaces in each mechanical room is a spare. The value of the actual requirement at 30¢ L would be $9,300, and for the higher requirement would be $13,000.

The portables are electrically heated using baseboard heaters. Considerable effort would be required to convert these units to waste heat use. No data was collected on these unit.

The school is not in a position to be supplied by-product heat from the existing diesel generators. Further, noise could be a problem if the units were relocated from an isolated area to the centre of the community. Space would also be somewhat of a problem. The park adjacent to the school is the best site available, but is valued by the community as a central recreation facility.

A base loaded unit of at least 73 kW would be required to be installed near the school to supply just one operating furnace. Space in the mechanical rooms is also limited. Small additions may be required.

At the present time, this installation is not a candidate for diesel heat supply, and even a smaller cogeneration unit such as a larger Fiat Totem type installation would be difficult to justify based on the heating fuel costs.

6.4.3 MNR Armstrong Field Office

The Ministry of Natural Resources operates a field office and bunkhouse in Armstrong. Included on site are a small office building, a two storey bunkhouse, a maintenance garage, a warehouse, a guest house and several house trailers. Also on site are several helipads and weather and communication towers.

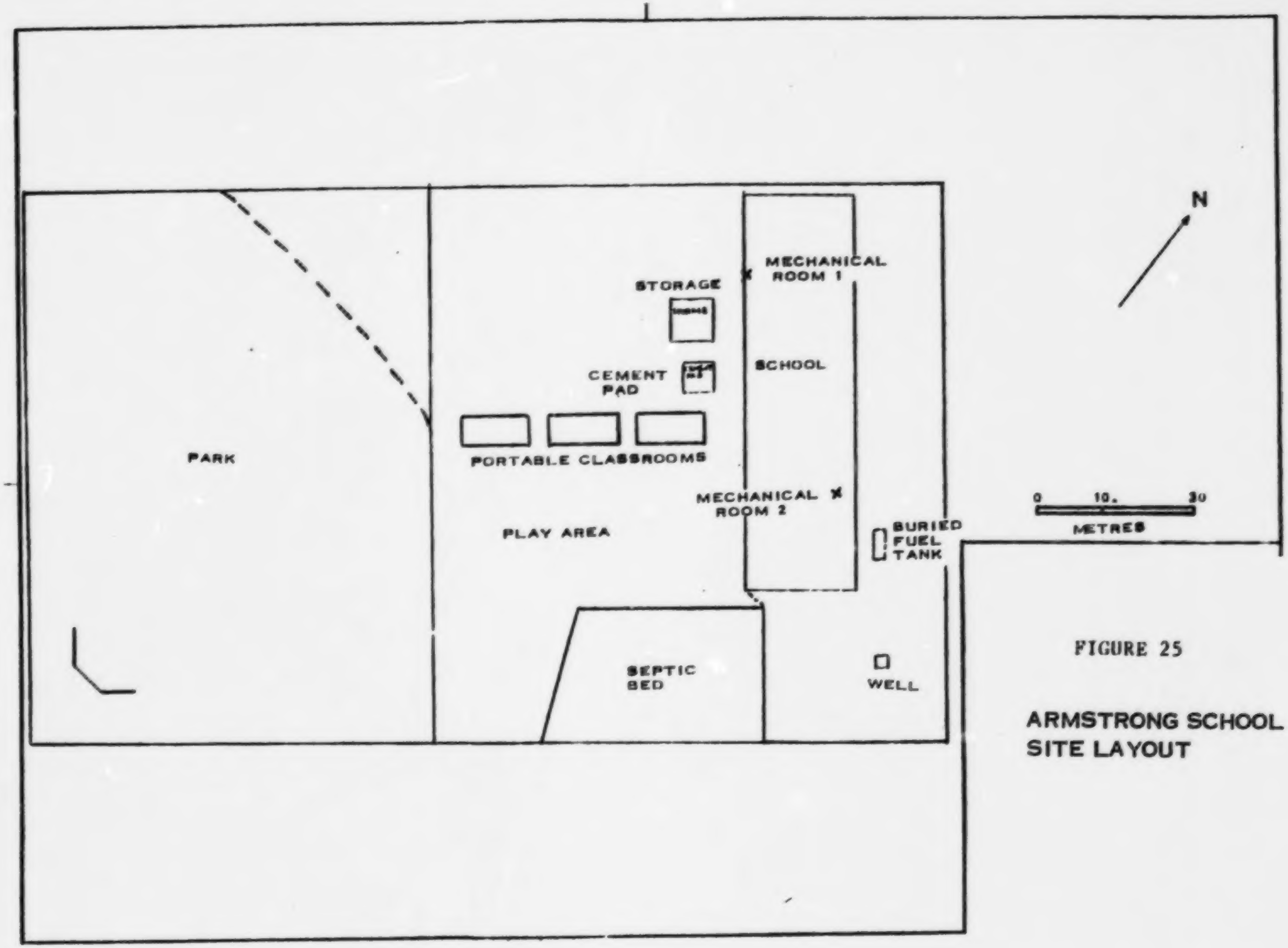

FIGURE 25

ARMSTRONG SCHOOL
SITE LAYOUT

Figure 26 presents a rough indication of the layout of this site and the heating facilities associated with each building.

The total fuel oil deliveries for the four major facilities in the period 1982/83 were 28,500 L. No details are available of how this fuel is distributed to individual buildings. The fuel quantities required by the degree-day/furnace size approach far exceed the actual delivery figures, even allowing for sparing of equipment and the unusually warm winter. Considerable oversizing of the equipment and low temperature operation must be practiced. Value of the fuel used in 1982/83 is approximately $8,600. Even assuming a 20 percent increase to account for unusual circumstances, the heating cost would be only $10,300. The MNR facility is at the east end of the community. Supply of diesel heat to the installation is infeasible. At the present rate of fuel consumption and cost a combined heat and power facility of any kind at this location would be difficult to justify.

6.4.4 CNR Bunkhouse and Station

Two of the largest facilities in Armstrong are the CN bunkhouse and the CN station.

The CN bunkhouse is a 1300 square metre building housing 72 bedrooms and numerous support and recreation facilities. It provides food and lodging facilities for CN's train crews at this division point between east and west regions.

The bunkhouse is heated by oil fuelled forced air furnaces in three mechanical rooms throughout the building. The first contains two 227,000 kJ/h in-line furnaces and a 153,000 kJ/h oil fuelled hot water heater. This is located on the main floor about midway along the east side of the building. The second installation consists of one 287,000 kJ/h Lennox oil furnace and the third, on the second level, is similar.

The layout of the mechanical rooms is very tight. There is very little room to consider additional equipment without considerable redesign of the facilities or some form of addition.

The fuel requirement for the first half of 1983 for the bunkhouse is $7,600. Based on a cost of $0.30/L, this would be about 51,000 L/a of fuel oil or about $15,300 per year. This is for a relatively warm season, but well below what one would expect for all furnaces operating on a degree-day calculation. It is expected that one of the two furnaces in the one furnace room may be a spare or that considerable efforts are taken at energy conservation. A more realistic value for heating might be 66,000 L/a which at todays's prices would be $20,000 per year.

The CN Armstrong Station is a very old building, poorly insulated, but largely unused. At the present time it is heated by a low pressure steam heating system supplied by three small 11.16 L/h boilers. One is usually operational and the other two are spares. The consumption of fuel oil is approximately 29,000 L/a at a total cost of $8,700.

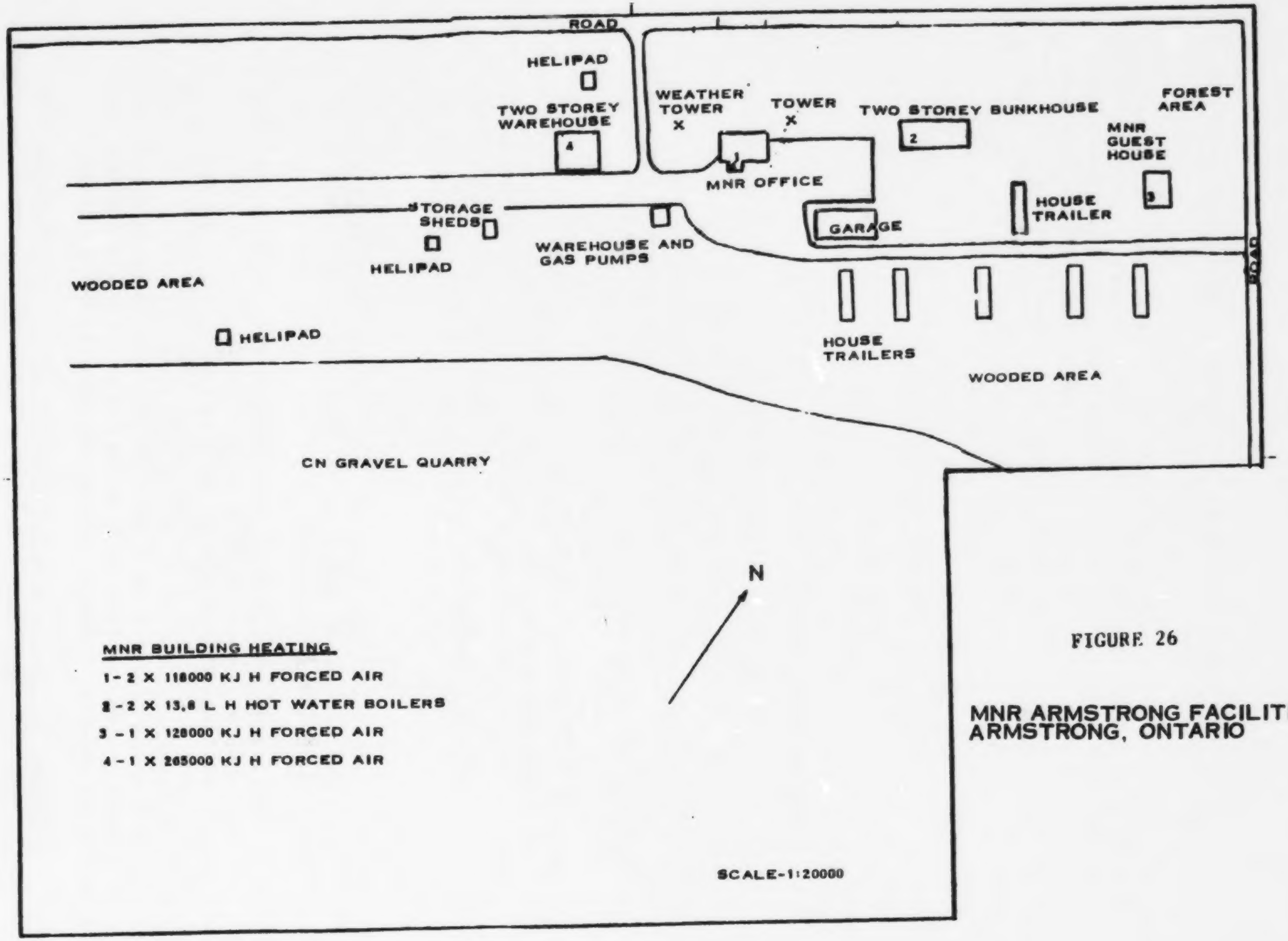

FIGURE 26

MNR ARMSTRONG FACILITIES
ARMSTRONG, ONTARIO

Overall CN's facilities have probably the best potential for diesel heat supply from the existing Ontario Hydro diesels in Armstrong. However, they are located a considerable distance, between 240 and 290 metres, and the laying of the necessary heat distribution piping might require some disruption of CN's operations. It is unlikely that the saving would be viewed as sufficient to justify the difficulties involved.

6.4.5 Armstrong Tree Nursery

A tree nursery is currently being constructed southwest of Armstrong, about 9.7 km from the centre of the community, at the northern tip of Mattice Lake (Figure 24).

The installation is a private venture designed to produce one million seedlings a year from a single rotation. Four greenhouses each 9.1 metres by 43.9 metres are required.

This facility is estimated to have a peak heat requirement of about 1,300,000 kJ/h. This appears to be below what would be expected under normal full year operation, but the installation will be operated on a single rotation basis. Thus is will only require heating in the period April to August. The Ministry of Natural Resources has no plans to have this installation go to a two crop rotation as fuel and servicing requirements here are too high.

The anticipated fuel requirement for this facility is approximately 60,000 to 80,000 litres of propane per year. At 32¢/L, the annual heating cost would be $19,200 to $25,600.

The tree nursery is at an excellent location for a wood based generating system. It is near ongoing Great West Timber/Nym Lake Timber operations, which could supply the wood needed for such a facility. The considerable quantities of by-product heat could then be applied to the greenhouse. If sufficiently low in cost, full-time operation of the nursery might even be considered.

This concept would be somewhat complicated by siting the plant much further from the community loads. Some losses would be incurred, and the control requirements could be more complex. It is not however infeasible to expect that these details would be overcome if the technical and economic feasibility were proven.

6.4.6 Potential Applications

Other applications considered were a greenhouse operation for vegetable production, a local laundromat and service facilities as suggested in the Jellicoe report.

The greenhouse and laundromat suggestions were not seen as being very feasible. In the case of the greenhouse operation, the local market could not justify it and the possible scale of operation could not economically compete for outside markets. In the case of the laundromat, the savings due to by-product heat use in the laundromat would not be a deciding factor in its implementation.

Concepts considered in the Jellicoe Resource Associate report[14] are ones which might consider by-product heat in siting a maintenance garage, an industrial park, a small log sawmill, but no definitive plans exist to implement any of them outside of the tree nursery. Economic times have hit the forest industry hard and expansion plans are limited at best. Armstrong may not see increased activity in terms of these sorts of facilities for some time.

6.5 Community Response to Electricity Generation and Diesel Heat Applications

As an unincorporated community, the community has no real central spokesman such as a mayor. For the purposes of this study, Mr. Jack Lundstrom[C-27], president of the local Chamber of Commerce provided some input.

Generally what Armstrong residents want in terms of electricity supply is to join the Ontario Hydro grid and get off of high cost diesel systems. Wood based generation is not viewed as a particularly attractive option. In the Jellicoe study and earlier Ontario Hydro work, the economics of electricity production were not greatly affected. There were some additional local employment opportunities, but the main community focus is on the price of electricity which was not significantly improved.

The community would support a wood based system, provided it was economic, and would hope it could form part of an industrial park setting encouraging other industry. They remain somewhat optimistic as to community development opportunities related to forest industry activities such as a regional maintenance centre, but recognize the realities of current economic times.

In terms of the use of by-product heat from either a diesel or wood fuelled facility, the response was really neither negative or positive. If a situation could save money and thereby lower electricity rates it would be favoured. However, noise was a major concern. Jack Lundstrom, the school principal and several local residents expressed concern over the noise which would result if a diesel were located less remotely from the community itself.

7.0 CONCLUSIONS

Based on the data obtained on the different remote communities and actual field surveys, the following conclusions can be made.

Sandy Lake

1. The area in and around Sandy Lake appears to have sufficient wood reserves to satisfy the needs of the community and to supply a wood based generating system of 200 kW.
2. Sandy Lake MTC facilities provide the closest opportunity to utilize heat from Ontario Hydro diesels and are representative of other communities such as Pikangikum.
3. Sandy Lake School provides an opportunity to examine a larger and a longer distance heat supply situation.
4. Sandy Lake School can be studied for a combined heat and power facility for partial supply of its heating load.

Big Trout Lake

1. Wood resources in Big Trout Lake are sufficient to supply a wood based generating system in addition to community needs, but restrictions on harvesting for electricity generation purposes in good growth areas and the generally poor growth over much of the reserve make it unadvisable.
2. The Bell Canada remote site staff residence provides a good opportunity to examine the economics of diesel heat recovery and supply from a diesel engine generator in remote communities.

Pikangikum

1. Wood resources in Pikangikum are insufficient to consider a wood based system.
2. Diesel heat opportunities in Pikangikum are similar to those in Sandy Lake, but on a somewhat smaller scale with less economic incentive.

Armstrong

1. The area around Armstrong is able to supply the wood necessary for a 300 kW woodbased electricity generation scheme. Arrangements would be required with the Ministry of Natural Resources and Domtar and local contractors.
2. Opportunities for by-product heat use are limited to the CN bunkhouse or station for existing diesels or to a tree nursery for a wood based system. In the case of CN, the difficulties may overshadow the benefits.

8.0 RECOMMENDATIONS

1. Armstrong, in view of interest in studying it by other groups as well as previous studies and higher production costs in more remote communities, should be dropped from further study.

2. Pikangikum, due to its lack of forest resources and the similarity of potential diesel heat applications to other sites, should be dropped from further study.

3. Heat supply from Ontario Hydro's diesel facility to the Bell Canada facility in Big Trout Lake should be examined in more detail. Wood use for electricity generation is not to be considered in view of the poor quality of forested areas available for use.

4. Based on the wood resources available and on the diesel heat use opportunities, the economic feasibility of combinations of the following situations in Sandy Lake should be examined in more detail.

   - heat supply to MTC's airport facilities
   - heat supply to Sandy Lake School
   - woodbased electricity generation

APPENDIX B

Economic Assessment

Background Data

Forecast

Price Escalation and Discount Rates

Year	Discount Rate	Diesel Fuel Escalation Rate	Equipment and Maintenance Materials	Labour	Alternate Diesel Fuel Escalation Rate	Alternate Discount Rate
1986	13%	9%	5.5%	6.0%	11%	9%
1987	13%	8.1%	6.0%	7.0%	11.8%	9%
1988	13%	8.1%	6.5%	8.0%	11.1%	9%
1989	14%	8.1%	6.5%	8.0%	11.1%	9%
1990	14%	8.1%	6.5%	8.0%	11%	9%
1991	14%	9%	6.5%	8.0%	9%	9%
1992	13%	9%	6.5%	8.0%	9%	9%
1993	13%	9%	6.5%	8.5%	9%	9%
1994	13%	9%	6.5%	8.5%	9%	9%
1995	13%	9%	6.5%	8.5%	9%	9%
1996	12%	9%	6.5%	8.5%	9%	9%
1997	12%	9%	6.5%	8.5%	9%	9%
1998	12%	9%	6.0%	8.0%	9%	9%
1999	12%	9%	6.0%	8.0%	9%	9%
2000	11%	9%	6.0%	8.0%	9%	9%
2001	11%	9%	6.0%	8.0%	9%	9%

Labour Costs

Wood Generation Plant (1985)	-	\$13^{35}/Hr + 30 percent benefits, etc. Ontario Hydro Divisional and Corporate Overhead not included).

Wood Harvesting (1985)	- Skidder/Tractor Operator	-	\$14/h
	- Chipper/Truck Driver	-	\$12/h
	- Cutter	-	\$12/h
	- Planters	-	\$10/h

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25. John Robinson, Robinson, Merritt and DeVries, Toronto. Re: Air photo interpretation and timber resources.

26. Morris McKay, 807+475-2110. Great Lakes Paper Company, Thunder Bay. Operations of Great Lakes Paper Company in the Armstrong area.

27. Jack Lundstrom, Armstrong Chamber of Commerce.

28. Peter George, Getty Mines, Toronto. Re: Gold mine project near Sandy Lake with potential hydraulic applications.

29. Don Lowman, 807+577-6451. Ontario Ministry of Transportation and Communication. Survey and Planning Section, P.O. Box 1177, Thunder Bay Ontario P7C 4X9. Re: Air photos of facilities in Sandy Lake, Pikangikum and Armstrong. Winter roads cost data.

30. Art Manly, Ministry of Natural Resources, Timber Sales. Toronto Office, Air photo interpretation. 965-6914.

31. Mrs. Atkinson, Zone Hospital, Health and Welfare Canada, Sioux Lookout, 807+737-3030. Re: Nursing station fuel consumption.

32. Rick Monzon, Policy and Planning Secretariat, Ministry of Natural Resources Toronto, Ontario, 965-8422 (Mike Millan). Re: Parks policy in Northern Ontario.

33. G.K. Sinclair, Bell Canada - Thunder Bay Remote Facilities Physical Plant 623-1539. Re: Big Trout Lake Bell Canada facility fuel consumption and layout.

34. Trevor Woods, Fire Management and Aviation Centre, Ministry of Natural Resources 705+942-1800. Re: Forest fire activity in Northern Ontario.

35. Mr. McDonald, Getty Mines, Toronto, 863-0487.

36. Jeff Patterson, Great West Timber, 807+344-8466; Asst. to Tom Ingles. Re: Great West Timber's operations in Armstrong area.

37. Bill Raney, Ministry of Transportation and Communications 807+577-6451. Re: MTC airport facilities and fuel consumption.

38. Diane Rombough, RME, National Air Photo Library, 615 Booth Street Rm 180, Ottawa Ontario K1A 0E9, 613+955-4560.

39. S. Pala, Ontario Centre for Remote Sensing.

40. Dennis Taylor, Ontario Research Foundation. Re: Diesel engines for wood gas 822-4111.

41. Nick Coleman, Energy Conservation, Canadian National Railroad, 860-2926. Re: CN heating fuel use in Armstrong.

42. Tom Rudolph (Dell Parkers), Ministry of Natural Resources, North Central Region. Regional Forester. 807+475-1251.

43. George Korstinen, Nipigon District Manager, 807+887-2120 (Armstrong).

44. Al Matthews (Kal Lajeunefse), Ministry of Natural Resources, Northwest Region, Kenora. 807+568-3111.

45. Hans Von Cube (Bill McIlwaine), ministry of Northern Affairs, 844+475-1585.

46. Andy Simons, Ministry of Natural Resources, Fire Management and Aviation Centre, Sault Ste. Marie, 942-1800, ext. 39. Re: Forest fire activity.

47. Mike Dominion (Jim Callon), DIAND, Sioux Lookout, Technical Services. Re: Sandy Lake projects.

48. Bob Davies, Pacific Western Airlines, Edmonton. Re: Rental.

49. Colin Laybourne, Laybourne Esso, Armstrong. 807+583-2095. Re: Fuel consumption data in Armstrong.

50. Ken Fulton, Public Works Canada, 244-4186, 4900 Yonge Street. Re: Sandy Lake school layout.

51. Milan Novac, Ministry of Natural Resources, Wildlife Section, 965-3345. Re: Effects of forestry operations on traplines in BTL and Sandy Lake.

52. John Byrne, Ministry of Natural Resources (2541), Wildlife Section. Re: Traplines in BTL and Sandy Lake.

53. Brian Newstead, Ontario Hydro Rural Service Superintendent. Re: Operation of Ontario Hydro remote site installations.

54. Jack Hooker, Austin Airways, Pickle Lake Base Manager. Re: Fuel supply to remote communities.

55. Gord Nesveski, Bell Canada. Re: Big Trout Lake Bell facility.

56. Ernie Carlson, Department of Indian Affairs and Northern Development, Technical Services, Thunder Bay. Re: Big Trout Lake facilities.

57. Koval Brothers Transport. Re: Transport to Sandy Lake.

58. D.R. Johnson, Regional Director, MNR Kenora. Re: Forest operations in Sandy Lake.

59. J.F. Goodman, Director, Aviation and Fire Management Centre, MNR Sault Ste. Marie.

60. Charles Trasher, Environment Service, Big Trout Lake. Re: Maintenance in Big Trout Lake.

61. Clint Quinn, Acting Environment Station Manager, Big Trout Lake. Re: Big Trout Lake weather station.

62. Mr. Dudley, Big Trout Lake school principal.

63. Chief Gerald McKay, Big Trout Lake Band Re: Band requirements.

64. Chris Birch, Big Trout Lake Hudson's Bay. Re: Diesel reliability and local market for vegetables.

65. Chief Joshua Suggashie, Pikangikum Band. Re: Band requirements.

66. Chief Josias Fiddler, Sandy Lake Band. Re: Band requirements.

67. F. McKay, Sandy Lake Hudson's Bay store.

68. Mark Olack, Armstrong school principal.

69. Fred Porter, Northern District School Board supervisory principal.

70. R.M. Whitings, W.L. Petitjean, Skinner Engine Company, P.O. Box 1149, Erie, Pennsylvania 16512, 814+454-7013. Re: Steam engines.

71. J.D. Dure, Mechron Energy Ltd., 2437 Kaladar Ave, Ottawa, K1V 8B9, 613+733-3855. Re: Remote site diesels and heat recovery.

72. D. Ferguson, Ferguson, Simek, Clark Limited, 4910-53rd St., Yellowknife, N.W.T., X1A 2P4, 403+920-2882. Re: Waste heat recovery.

73. T. Thomson, KMW Inc., 150 White Oak Rd., London, Ontario N6E 3A1 519+686-1771. Re: Wood boiler and handling.

74. J.T. Pappain, PetroSun Inc., 5035 Timberlea Blvd, Unit 5, Mississauga, 14Y 2N5, 416+624-5591. Re: Wood gasification.

75. D.J. Bennewies, Robert Bell Industries Ltd., P.O. Box 70, Seaforth, Ontario, N0K 1W0, 519+527-0600. Re: Wood boilers.

76. J.R. Mott, Mottpac Boilers, 1028 Royal York Road, Toronto M8X 2G4, 416+231-8616. Re: Wood boilers.

77. Kleiber and Schulz Inc., Fritz Werner Fluidized Bed Gas Generators, 1 Huntington Quadrange, Melville, N.Y. 11747. Re: Wood gasifier.

78. J. Wilson, Energesis Control Systems (Texas Instruments), Markham, Ontario, 416+294-5360. Re: Control Systems.

79. Ahron Nahmias, Control and Metering Ltd., Toronto, 416+626-8411. Re: Control Systems.

80. Charles Cobb, Woodward Governor Company, 1000 E. Drake Rd., Fort Collins, Colorado 80522, 303+482-5811. Re: Steam engine governing.

81. J. Hayward, Culligan of Canada, Toronto 416+449-5100. Re: Water treatment.

82. G.H. Gatson, Betz Laboratories, Toronto, 416+259-5118. Re: Water treatment.

83. L. Baxter, Ministry of the Environment, Northwestern Region, Thunder Bay, 807+474+1205. Re: Water quality.

84. Luke Williams, Modern Steam Power, 369 Dewitt Rd., Stoney Creek, Ontario, L8E 2T1, 416+664-2121. Re: Wood boilers.

85. Peter Akroyd, Northfab Systems, P.O. Box 202, Stratford, N5A 6T1 519+271-5530. Re: Wood boilers.

86. Gord Duncan, Affiliated Engineering Equipment - Coppus Turbines, Toronto, 416+624-9751. Re: Steam turbines.

87. D.M. Duthie, McRae Engineering Equipment, Toronto, 416+422-3735. Re: Steam turbines.

88. Dave Sowrey, Truck and Tractor Equipment Limited, Mississauga, 416+678-2222. Re: Wood harvesting mobile equipment.